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A Computer Program To Generate Equations of Motion Matrices, L217 (EOM)

Volume II: Supplemental System Design and Maintenance Document

R. E. Clemmons and R. I. Kroll

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NASA Contractor Report 2852

A Computer Program To Generate Equations of Motion Matrices, L217 (EOM)

Volume II: Supplemental System Design and Maintenance Document

R. E. Clemmons and R. I. Kroll
Boeing Commercial Airplane Company
Seattle, Washington

Prepared for
Langley Research Center
under Contract NAS1-13918

National Aeronautics
and Space Administration

**Scientific and Technical
Information Branch**

1979

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1.0 SUMMARY

The program L217 (EOM) is structured as a system of overlays, one main overlay with four primary overlays and their associated secondary overlays.

Input into the program is made via cards and magnetic files (tapes or disks). Output from the program consists of printed results and magnetic files containing matrices of equations of motion coefficients and aerodynamic forces.

Although L217 (EOM) serves as a module of the DYLOFLEX system, it can be operated as a standalone program. Subroutines used by L217 (EOM) include routines obtained from the standard FORTRAN library, and routines from the DYLOFLEX alternate subroutine library.

2.0 INTRODUCTION

The computer program L217 (EOM) was developed for use as either a standalone program or as a module of a program system called DYLOFLEX (ref. 1) (see fig. 1). The Equations of Motion program (L217) was designed to meet the DYLOFLEX contract requirements as defined in reference 2. These requirements specify the need for a program that can assemble and generate data needed to formulate the equations of motion for a flight vehicle, and the necessary aerodynamic forces that can be used in the flight loads analysis of that vehicle.

The program was designed, coded, and documented according to the programming specifications developed for DYLOFLEX[1].

The objective of this volume is to aid those persons who will maintain and/or modify the program in the future. To meet this objective the following items are discussed:

- Program design and structure
- Purpose and operation of each overlay
- Input, output, and internal data bases
- Test cases

---

[1] Clemmons, R. E.: *Programming Specifications for Modules of the Dynamic Loads System to Interface With FLEXSTAB.* Boeing-NASA Contract NAS1-13918 BCS-G0701, September 1975. (internal report)

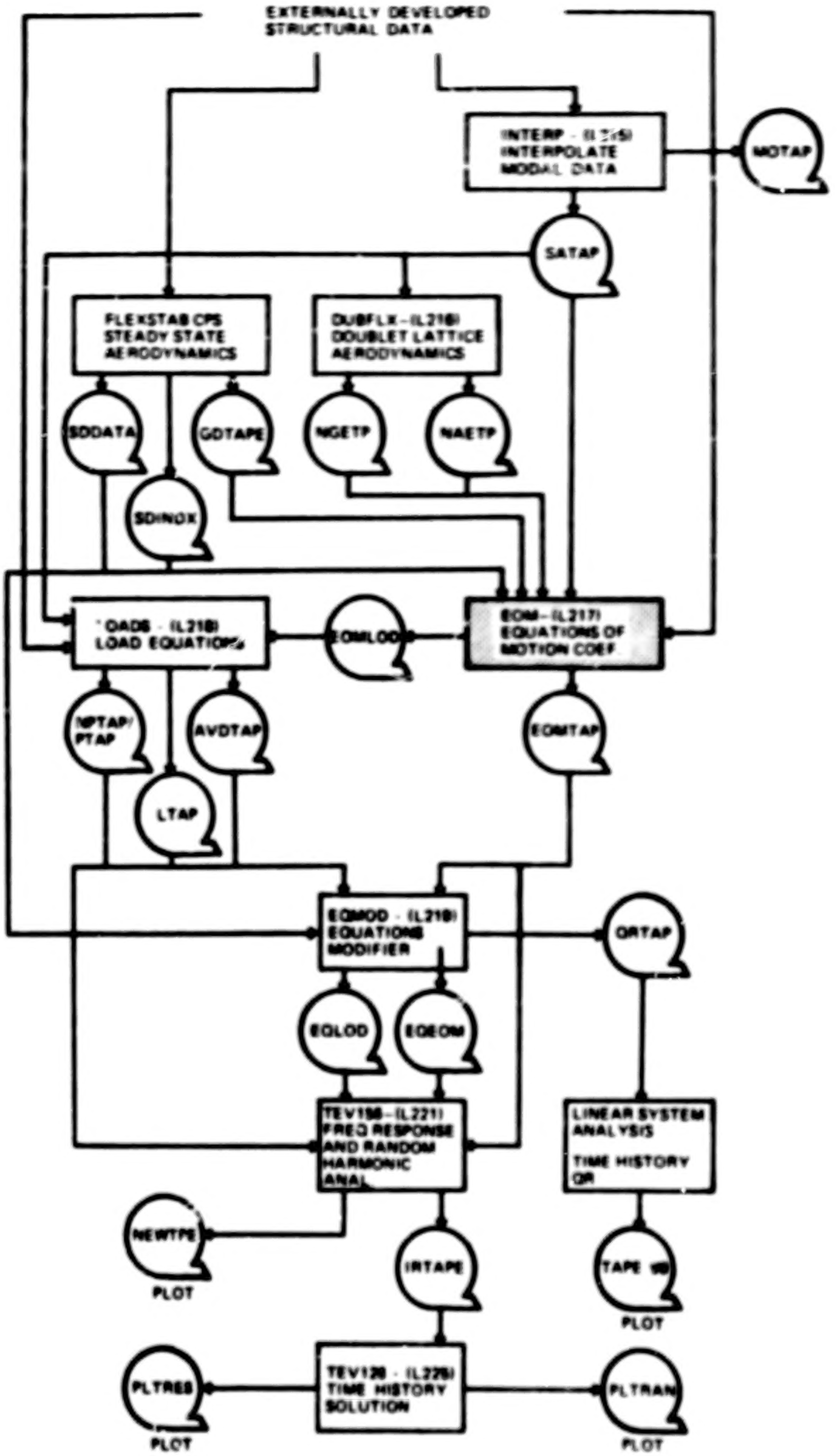

EXTERNALLY DEVELOPED STRUCTURAL DATA
INTERP - (L215) INTERPOLATE MODAL DATA
MOTAP
SATAP
FLEXSTAB CPS STEADY STATE AERODYNAMICS
DUBFLX - (L216) DOUBLET LATTICE AERODYNAMICS
SDDATA
GDTAPE
NGETP
NAETP
SDINOX
LOADS - (L218) LOAD EQUATIONS
EOMLOD
EOM - (L217) EQUATIONS OF MOTION COEF
NPTAP/ PTAP
AVDTAP
EOMTAP
LTAP
EQMOD - (L219) EQUATIONS MODIFIER
QRTAP
EQLOD
EQEOM
TEV156 - (L221) FREQ RESPONSE AND RANDOM HARMONIC ANAL
LINEAR SYSTEM ANALYSIS
TIME HISTORY QR
NEWTPE
PLOT
IRTAPE
TAPE 10
PLOT
PLTRES
PLOT
TEV126 - (L225) TIME HISTORY SOLUTION
PLTRAN
PLOT

Figure 1. – DYLOFLEX Flow Chart

3.0 PROGRAM DESIGN AND STRUCTURE

The program is structured as a system of overlays, the main overlay and four primary overlays with their associated secondary overlays (see fig. 2).

Main overlay	(L217,0,0)	Program L217vc
Primary overlay	(L217,2,0)	Program STRUCT
Primary overlay	(L217,3,0)	Program FLXAIC
Primary overlay	(L217,4,0)	Program DLAIC
Primary overlay	(L217,5,0)	Program DLPRES

The main overlay named L217vc (the v and c are version and correction identifiers. See sec. 3.1) reads data cards that direct the execution of the primary overlays. It also aids communication between the primary overlays via labeled common blocks.

The 2,0 primary overlay, STRUCT, generates the equations of motion matrices that are dependent upon the structural data only. They are:

$[M_1]$	Generalized stiffness matrix
$[M_2]$	Generalized damping matrix
$[M_3]$	Generalized inertia matrix

The remaining primary overlays generate the equations of motion matrices that are dependent upon the aerodynamic data. They are:

$[M_4]$	Generalized aerodynamic stiffness matrix
$[M_5]$	Generalized aerodynamic damping matrix
$\{f_\ell\}$	The distance(s) from the gust reference point to the control point(s) of the gradual penetration gust zones.
$[\bar{\Phi}]$	The generalized gust forcing function matrix

The 3,0 primary overlay, FLXAIC, generates the aerodynamic equations of motion that are based upon the FLEXSTAB (ref. 3) AIC (aerodynamic influence coefficient) matrices.

The 4,0 primary overlay, DLAIC, generates the aerodynamic equations of motion based upon Doublet Lattice (L216) (ref. 4) AIC matrices.

The 5,0 primary overlay, DLPRES, generates the aerodynamic equations of motion based upon generalized forces and unsteady pressures from Doublet Lattice (ref. 4).

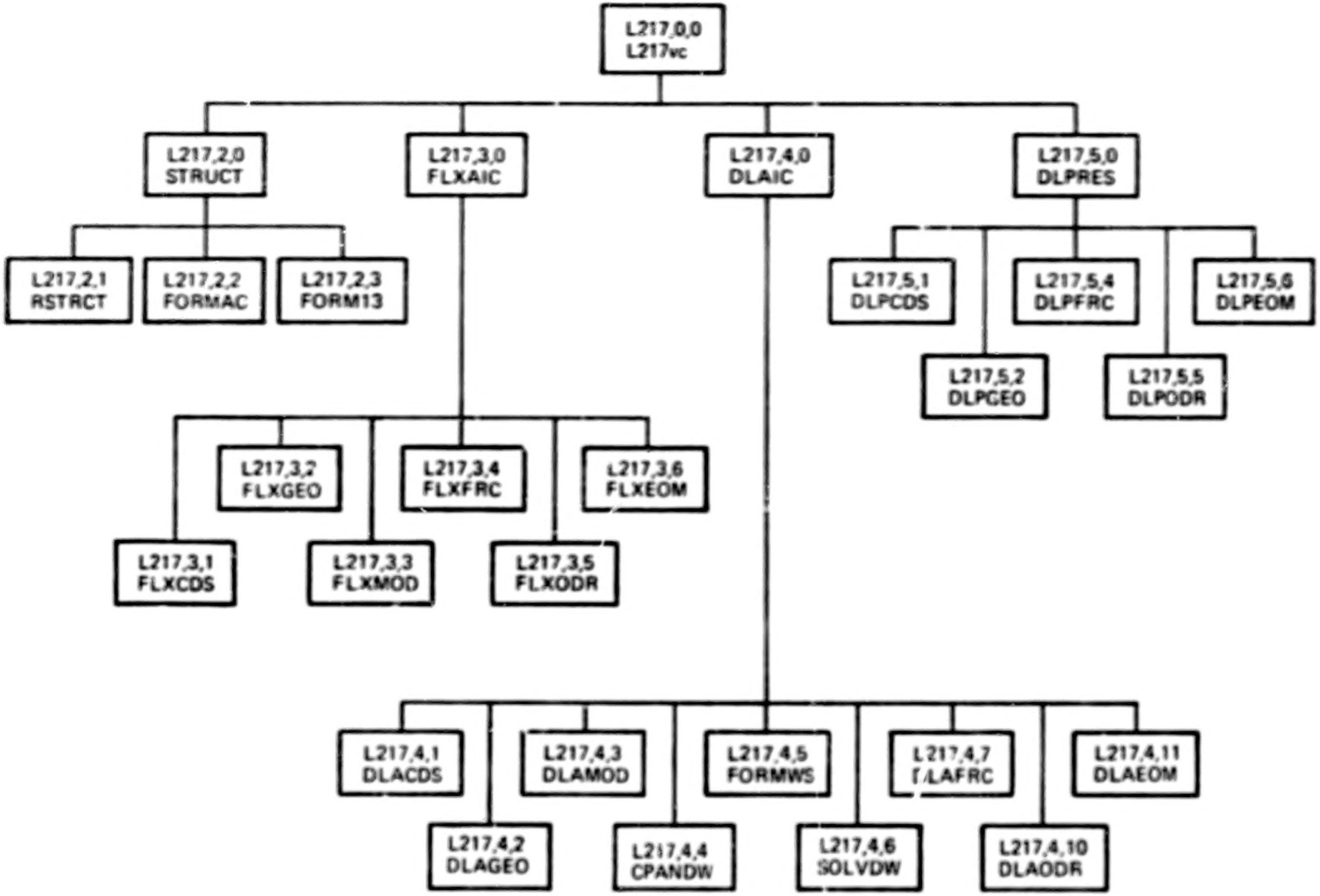


Figure 2. —Overlay Structure of L217 (EOM)

Although L217 (EOM) serves as a module of the DYLOFLEX system, it is operated as a standalone program. When the program is run by itself, it becomes the user's responsibility to generate input data in the format required by the program. (See vol. I of this document for a description of the required data and formats.) L217 (EOM) is heavily dependent upon data generated prior to its execution. Figure 3 displays the different files, which L217 (EOM) may require, according to user specified options. The following programs produce or read the files displayed in figure 3.

Program	**Reference number**
FLEXSTAB	3
L216(DUBFLX)	4
L215(INTERP)	5
L221(TEV156)	6
L219(EQMOD)	7
L218(LOADS)	8

The program requires subroutines which are not part of the L217 (EOM) code. Some routines are automatically obtained from the standard CDC FORTRAN library when the program is loaded. Others, however, are stored in the DYLOFLEX alternate subroutine library that must be declared at the time of loading. Subsequent sections describe each overlay separately and contain tables displaying the routines called and the library in which they are located. All subroutines have one entry point.

This volume describes the program in a macro sense. A more detailed discussion appears in the comments contained in the program source code. Each routine contains a preface describing the routine's purpose, author, analytical steps, modification history, input data, output data, glossary of variables, and a list of other routines called. Embedded within the executable code are comments labelling each section and explaining logical branches.

3.1 OVERLAY(L217,0,0), L217vc

The main overlay of L217 (EOM) is named L217vc where:

v Is a letter indicating the program version

c Is an integer indicating the correction set applied to the v version

Purpose of L217vc

L217vc performs certain bookkeeping tasks, directs the execution of the primary overlays, and aids communication between primary overlays via labeled common blocks.

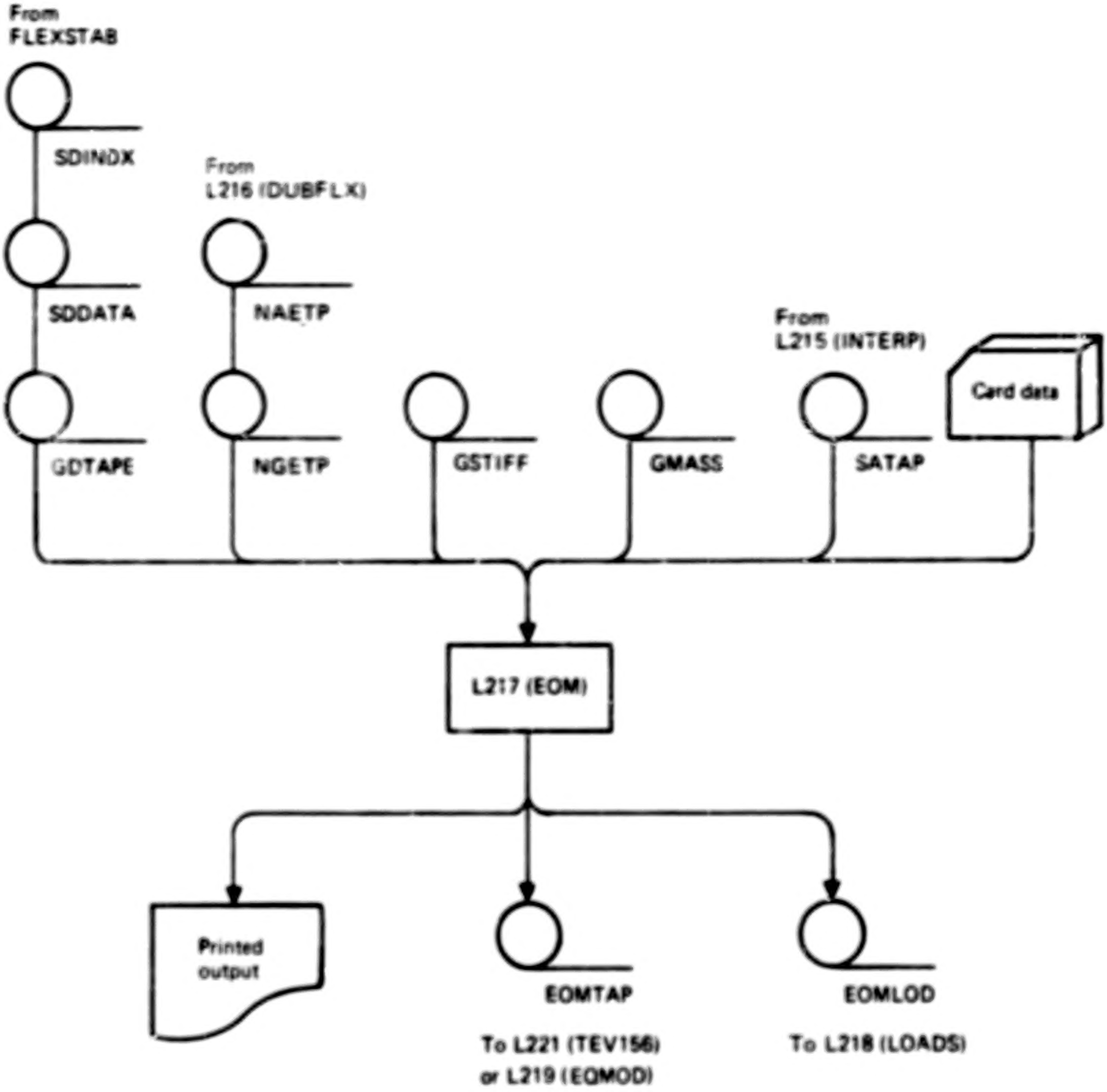


Figure 3. — L217 (EOM) Communication Via External Files

Analytical Steps of L217vc

The L217vc performs its tasks in the following steps:

1. The subroutine PRGBEG is called to place the program header on the printed output.

2. A data card is read. It must begin with $EOM to ensure that the input file is correctly positioned. If it does not contain $EOM, execution is terminated.

3. A program directive card is read, printed, interpreted, and acted upon according to the following logic:

    a. If the keyword is $TITLE jump to step 3 again.

    b. If the keyword is $NONSTOP set the nonstop switch and jump to step 3 again.

    c. If the keyword is $STRUCTURAL, jump to step 4.

    d. If the keyword is $AERO followed by FLEXSTAB jump to step 5.

    e. If the keyword is $AERO followed by DOUB...AIC jump to step 6.

    f. If the keyword is $AERO followed by DOUB...PRES jump to step 7.

    g. If the keyword is $QUIT jump to step 8.

4. Overlay (L217,2,0), STRUCT is called. When it is finished, control returns to step 3.

5. Overlay (L217,3,0), FLXAIC is called. When it is finished, control returns to step 3.

6. Overlay (L217,4,0), DLAIC, is called. When it is finished, control returns to step 3.

7. Overlay (L217,5,0), DLPRES, is called. When it is finished, control returns to step 3.

8. Subroutine PRGEND is called to place the program termination message on the printed output file, and the execution is terminated.

If errors were detected, the program jumps to step 8.

The macro flow chart of this overlay is shown in figure 4.

The routines called are displayed in table 1.

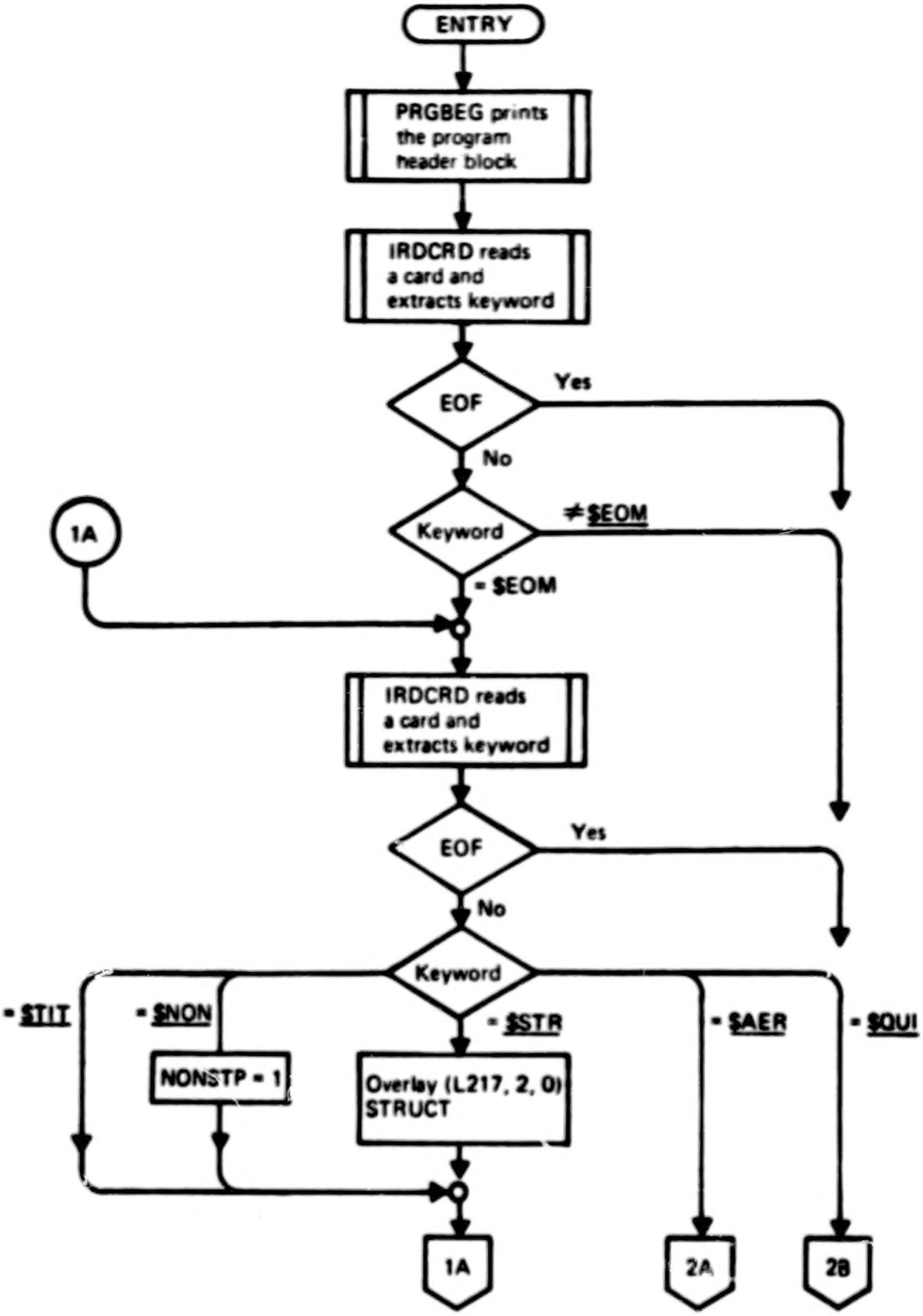

ENTRY
PRGBEG prints the program header block
IRDCRD reads a card and extracts keyword
EOF
Yes
No
1A
Keyword
≠$EOM
= $EOM
IRDCRD reads a card and extracts keyword
EOF
Yes
No
Keyword
= $TIT
= $NON
= $STR
= $AER
= $QUI
NONSTP = 1
Overlay (L217, 2, 0) STRUCT
1A
2A
2B

Figure 4. – Macro Flow Chart of Overlay (L217, 0, 0), L217 vc

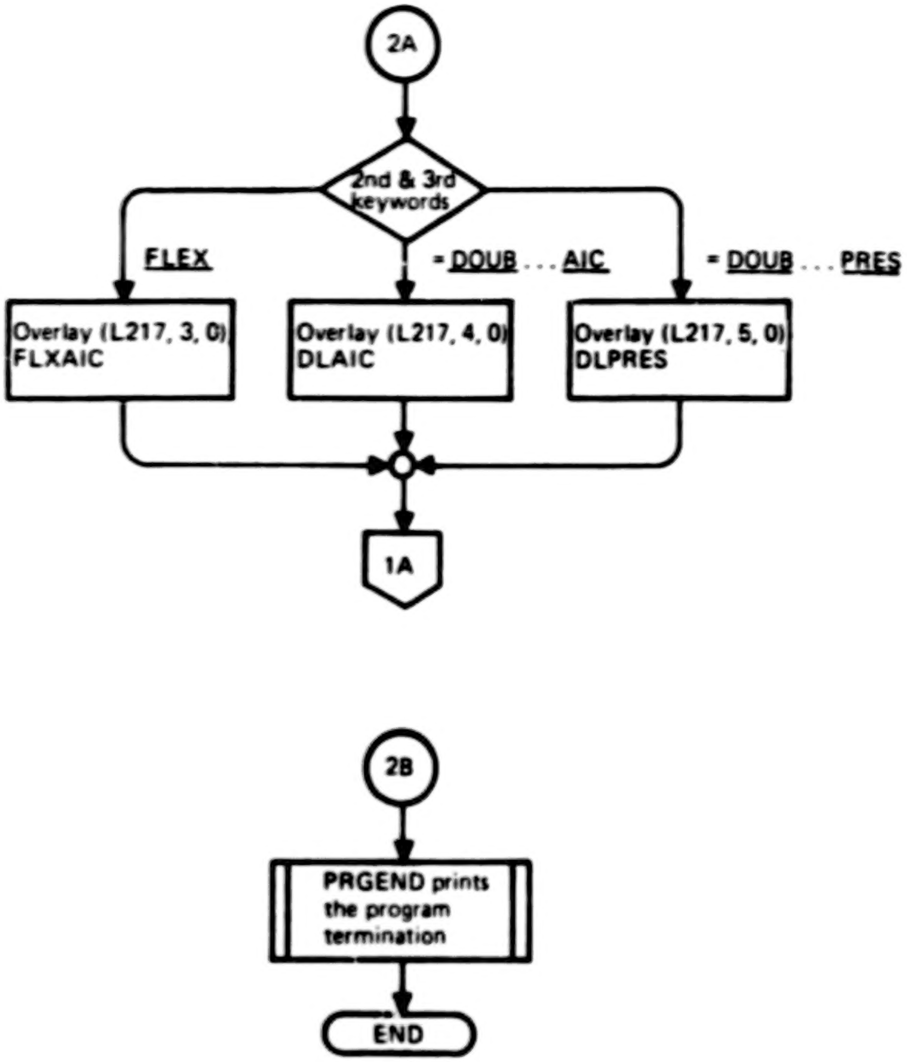

2A
2nd & 3rd keywords
FLEX
= DOUB . . . AIC
= DOUB . . . PRES
Overlay (L217, 3, 0) FLXAIC
Overlay (L217, 4, 0) DLAIC
Overlay (L217, 5, 0) DLPRES
1A
2B
PRGEND prints the program termination
END

Figure 4. — (Concluded)

Table 1. — Routines Called By L217vc

```
OVERLAY(L217,0,0)

PROGRAM L217vc

---------------------------------------------

DLAIC      -     OVERLAY(L217,4,0)

DLPRES     -     OVERLAY(L217,5,0)

FLXAIC     -     OVERLAY(L217,3,0)

FNDKEY*

IRDCRD*

PRGBEG*

PRGEND*

RETURNF*

STRUCT     -     OVERLAY(L217,2,0)
```

* indicates a routine obtained from
the DYLOFLEX alternate subroutine library.

All others are local to L217(EOM).

I/O Devices of L217vc

The L217vc reads program directive cards and writes them on the printed ouput file. All other I/O accomplished by L217 (EOM) is done in lower level overlays.

3.2 OVERLAY(L217,2,0), STRUCT

Purpose of STRUCT

The L217 (EOM)'s first primary overlay is named STRUCT. STRUCT generates the equations of motion matrices $[M_1]$, $[\dot{M}_2]$, and $[M_3]$.

Analytical Steps of STRUCT

STRUCT performs its task in the following steps:

1. Initialize the error count and print a message indicating that STRUCT is being executed.

2. Call overlay (L217,2,1) RSTRCT to read the card input data directing the structural data processing.

3. If control surface freedoms are to be added to the existing generalized mass and stiffness matrices, call overlay (L217,2,2), FORMAC, to form the matrices $[A]$ and $[C]$. (See sec. 3.2.2.)

4. Call overlay (L217,2,3), FORM13, to generate the matrices $[M_1]$, $[\dot{M}_2]$, and $[M_3]$ and save them on the temporary storage file named S2L217.

5. Print a message indicating that STRUCT is finished and return to the main overlay, L217.

If errors were detected in the secondary overlays, the program jumps to step 5.

The macro flow chart of this overlay is shown in figure 5.

The routines called are displayed in table 2.

I/ODevices of STRUCT

STRUCT prints two messages on the output file; NOW IN STRUCT...and STRUCT IS FINISHED... . All other file communication in STRUCT is performed by its secondary overlays. Figure 6 shows the files providing input and output to STRUCT's overlays.

In subsections 3.2.1 through 3.2.3, the matrices read from and written onto each file are listed. (See sec. 6.4 of vol. I, *Engineering and Usage*, for detailed description of the format and content of files used for external communication.) Section 3.6.3 of this volume contains the same information for files used only within L217 (EOM) for temporary storage.

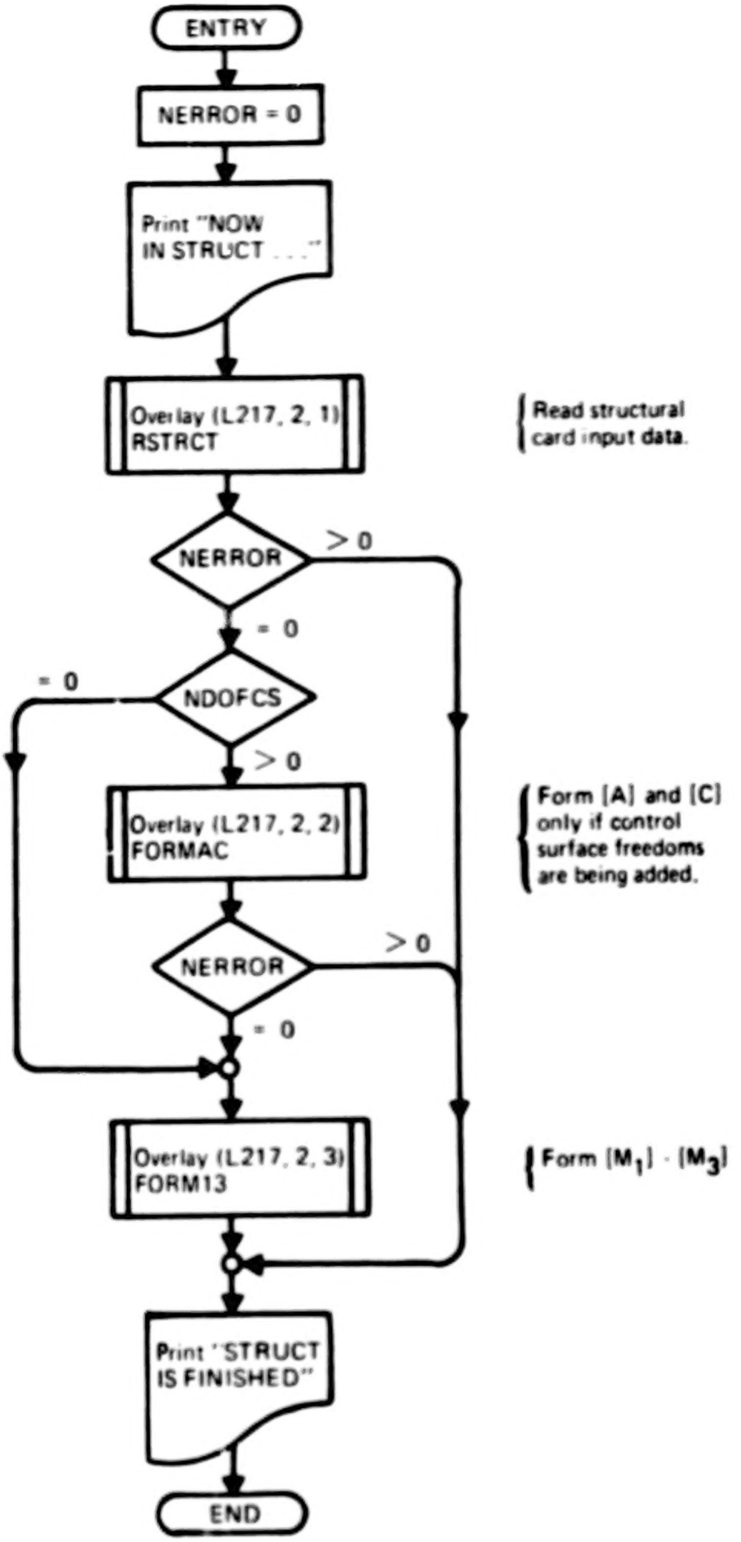

ENTRY
NERROR = 0
Print "NOW IN STRUCT . . ."
Overlay (L217, 2, 1) RSTRCT
Read structural card input data.
NERROR
> 0
= 0
NDOFCS
= 0
> 0
Overlay (L217, 2, 2) FORMAC
Form [A] and [C] only if control surface freedoms are being added.
NERROR
> 0
= 0
Overlay (L217, 2, 3) FORM13
Form [M1] · [M3]
Print "STRUCT IS FINISHED"
END

Figure 5. – Macro Flow Chart of Overlay (L217, 2, 0), STRUCT

Table 2. — Routines Called by STRUCT

```
OVERLAY(L217,2,0)

PROGRAM STRUCT

---------------------------------------------


FORMAC     -     OVERLAY(L217,2,2)

FORM13     -     OVERLAY(L217,2,3)

RSTRCT     -     OVERLAY(L217,2,1)
```

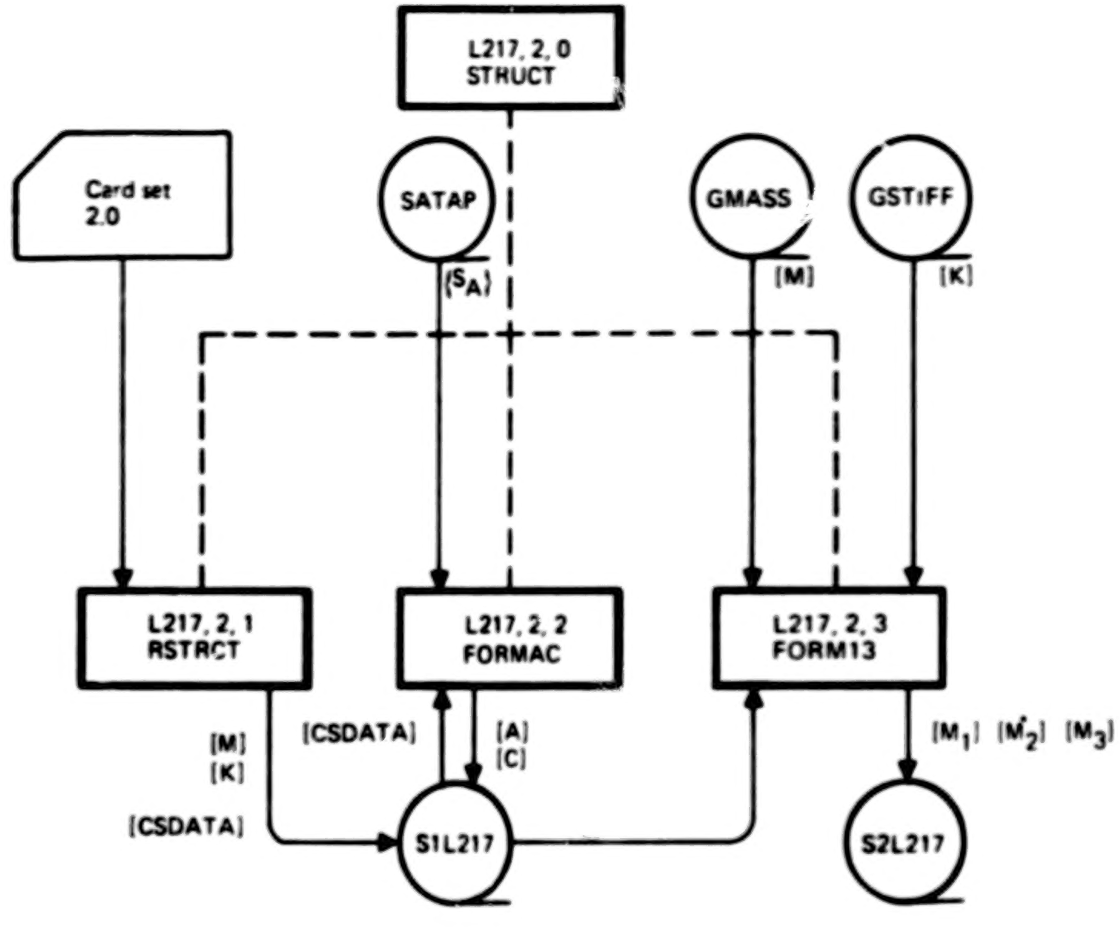


Figure 6. – Files Providing Input/Output to STRUCT Overlays

3.2.1 OVERLAY(L217,2,1), RSTRCT

Purpose of RSTRCT

RSTRCT reads the card input data directing the processing of structural data. Options and constants are stored in labelled common blocks for later use. If either the generalized mass or generalized stiffness matrix is read from cards, it is written onto the temporary storage file named S1L217 for later retrieval by overlay (L217,2,3), FORM13.

The macro flow chart of this overlay is shown in figure 7.

The routines called are displayed in table 3.

I/O Devices of RSTRCT

RSTRCT reads card images from the input file and prints them on the output file along with descriptive comments and any necessary diagnostics.

When either the generalized mass matrix or generalized stiffness matrix is input on cards, RSTRCT writes them onto the temporary storage file named S1L217 (see fig. 6).

3.2.2 OVERLAY(L217,2,2), FORMAC

Purpose of FORMAC

FORMAC is called to generate the matrices $[A]$ and $[C]$. The two matrices will become partitions of $[M_3]$, the generalized mass matrix. They represent control-surface, generalized coordinates being added to the original structural data.

Analytical Steps of FORMAC

FORMAC generates $[A]$ and $[C]$ in the following steps:

1. Open the files ICSTPE (containing the control surface data) and SATAP (the file of interpolation arrays). Set aside storage for the arrays $[\phi]$, $[M\mathring{C}S]$, and $[CSDATA]$.

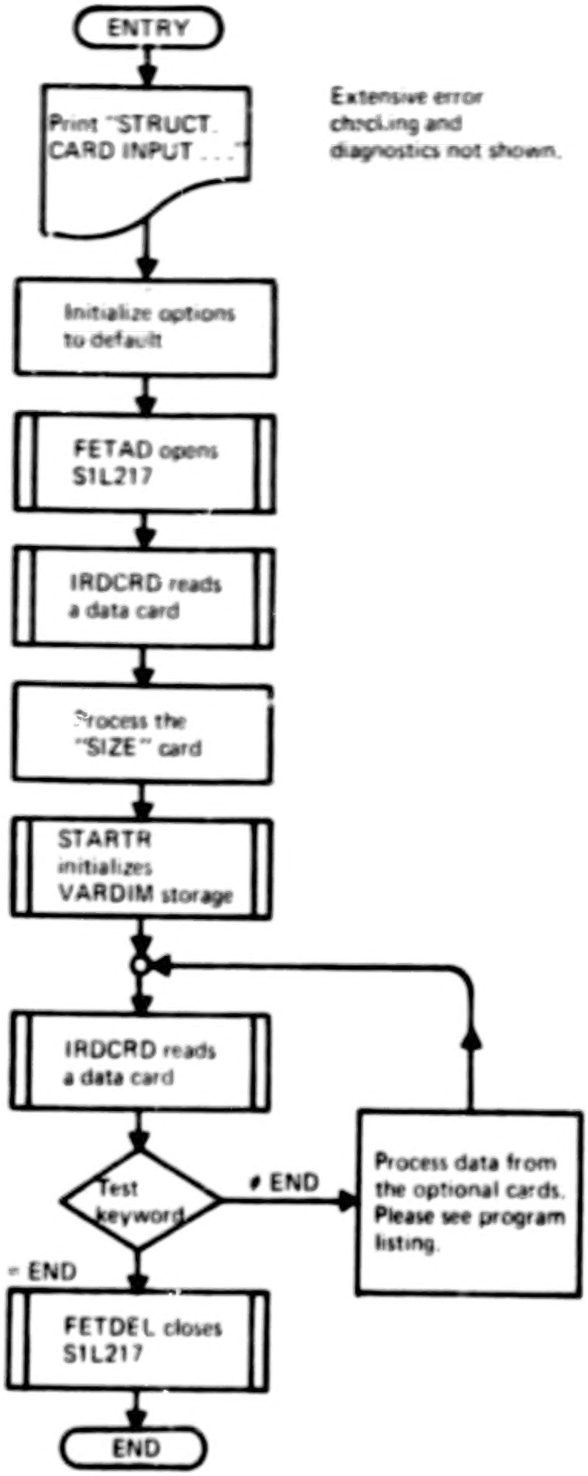
   Repeat steps 2 through 5 for each control surface adding freedoms; ICS = 1, NCSEF.

2. Read the nodal data for control surface IS from S1L217.

3. Call BLDMCS to add the control surface mass and inertia data to $[M\mathring{C}S]$.

4. Read the interpolation array $\{SA\}$ for the control surface from SATAP.

5. Interpolate for the modal deflection and/or slopes as requested and build the matrix $[\phi]$.


ENTRY
Print "STRUCT. CARD INPUT . . ."
Initialize options to default
FETAD opens S1L217
IRDCRD reads a data card
Process the "SIZE" card
STARTR initializes VARDIM storage
IRDCRD reads a data card
Test keyword
≠ END
Process data from the optional cards. Please see program listing.
= END
FETDEL closes S1L217
END

Extensive error checking and diagnostics not shown.

Figure 7. – Macro Flow Chart of Overlay (L217, 2, 1), RSTRCT

Table 3. – Routines Called by RSTRCT

```
OVERLAY(L217,2,1)

PROGRAM RSTRCT

--------------------------------------------------


DELETR♦

RETAD♦

RETDEL♦

INITIR♦

IRDCRD♦

MATCRD

NAMFIL♦

RDCSCD            IRDCRD♦

SETMFL

STARTR♦

WRTETP♦
```

♦ indicates a routine from the **DYLOFLEX** alternate subroutine library.

6. Close the files ICSTPE and SATAP.

7. Initialize the file S1L217 and generate the temporary array.

$$[PCSTM] = [\phi_{CS}]^T \; [\mathring{M}CS]$$

8. Generate $[A]$ and write it on S1L217.

$$[A] = [PCSTM][\phi_{ST}].$$

9. Generate $[C]$ and write it on S1L217.

$$[C] = [PCSTM][\phi_{CS}].$$

10. Return to the calling program.

The macro flow chart of this overlay is shown in figure 8.

The routines called are displayed in table 4.

I/O Devices of FORMAC

FORMAC's communication via external files is displayed in figure 6.

FORMAC reads from the files:

S1L217	the control surface nodal data written there by RSTRCT
SATAP	the modal interpolaton array(s) specified by surface number on card input

FORMAC writes onto the file:

S1L217	the matrices $[A]$ and $[C]$

3.2.3 OVERLAY(L217,2,3), FORM13

Purpose of FORM13

FORM13 generates the structural equations of motion ($[M_1]$, $[M_2]$, and $[M_3]$) and saves them on the temporary storage file named S2L217.

Analytical Steps of FORM13

FORM13 performs its tasks in the following steps:

1. Initialize the output file S2L217 and variably dimensioned array storage. Initialize the array $[\mathring{M}_2]$, if structural damping was specified by the user.

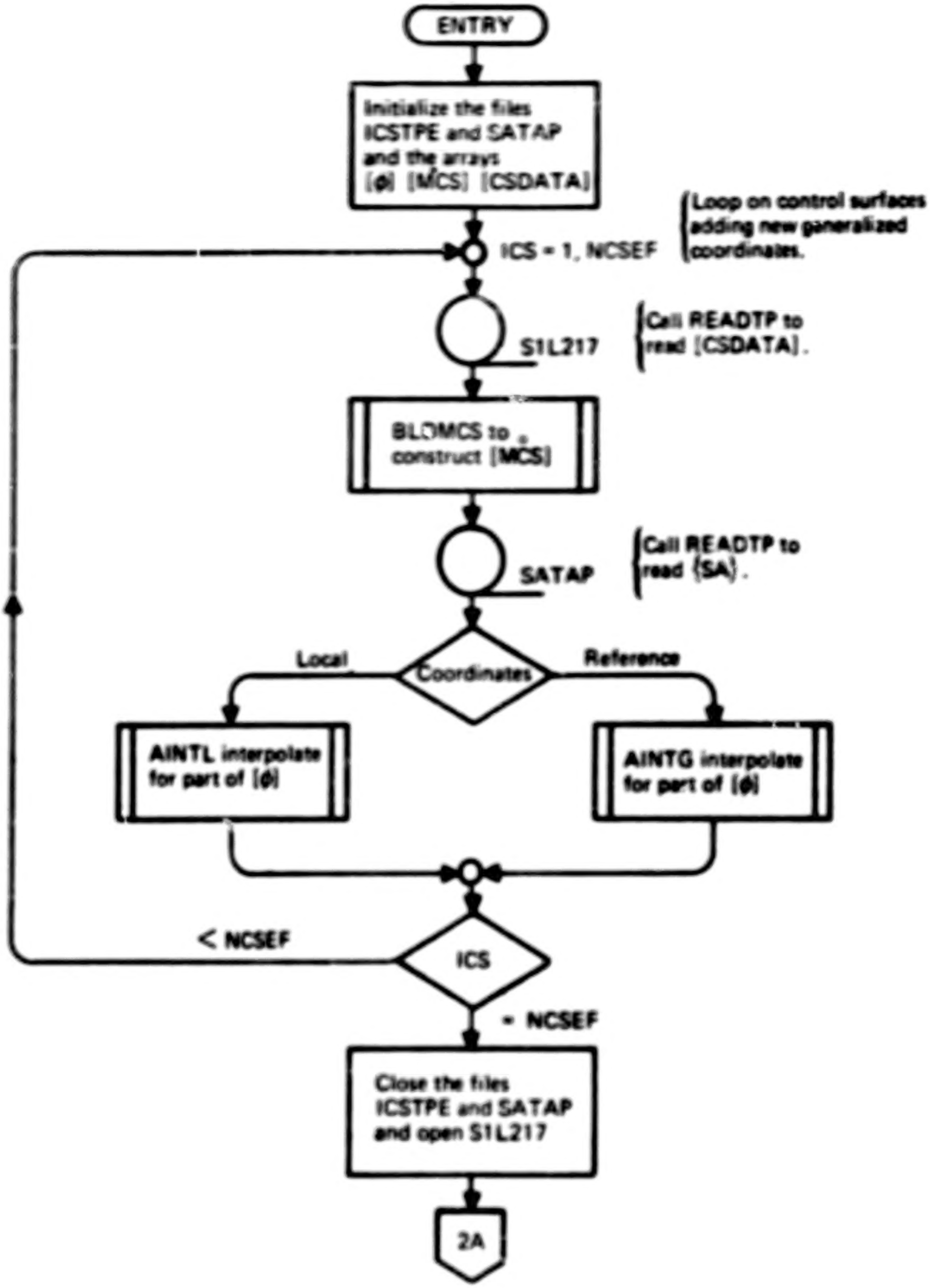

ENTRY
Initialize the files ICSTPE and SATAP and the arrays [ϕ] [MCS] [CSDATA]
ICS = 1, NCSEF
Loop on control surfaces adding new generalized coordinates.
S1L217
Call READTP to read [CSDATA].
BLDMCS to construct [MCS]
SATAP
Call READTP to read {SA}.
Local
Coordinates
Reference
AINTL interpolate for part of [ϕ]
AINTG interpolate for part of [ϕ]
< NCSEF
ICS
= NCSEF
Close the files ICSTPE and SATAP and open S1L217
2A

Figure 8. – Macro Flow Chart of Overlay (L217,2,2), FORMAC

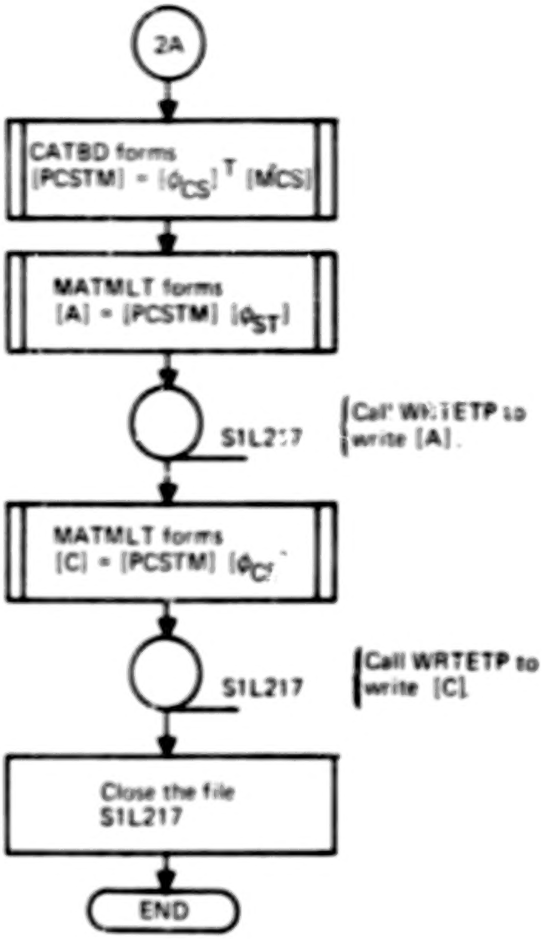

2A
CATBD forms
[PCSTM] = [ϕ_{CS}]^T [MCS]
MATMLT forms
[A] = [PCSTM] [ϕ_{ST}]
S1L217
Call WRTETP to write [A].
MATMLT forms
[C] = [PCSTM] [ϕ_{CF}]
S1L217
Call WRTETP to write [C].
Close the file
S1L217
END

Figure 8. – (Concluded)

Table 4. – Routines Called by FORMAC

```
OVERLAY(L217,2,2)

PROGRAM FORMAC

-------------------------------------------------


AINTG+

AINTL+

BLDMCS

CATBD

DELETR+

FETAD+

FETDEL+

INITIR+

MATMLT

PRINTM+

READTP+

SETMFL

STARTR+

WRTETP+
```

+ indicates a routine from the DYLOFLEX
  alternate suroutine library.

2. Initialize $[M_1]$, read the generalized stiffness matrix into its upper left partition, scale if requested, and write$[M_1]$ onto the file S2L217.

3. If structural damping was requested, read the damping factors into $[\dot{M}_2]$ and multiply them by the square root of the corresponding diagonal elements of $[M_1]$.

4. Erase $[M_1]$, initialize $[M_3]$, and read the generalized mass matrix into the upper left partition.

5. If structural damping was requested, multiply the elements of $[\dot{M}_2]$ by the square root of the corresponding diagonal elements of $[M_3]$, and write $[\dot{M}_2]$ onto S2L217.

6. Read the matrices $[A]$ and $[C]$ from S1L217 and store in $[M_3]$ as shown in the following equation, and write $[M_3]$ onto S2L217.

$$[M_3] = \begin{bmatrix} [M][A]^T \\ [A][C] \end{bmatrix}$$

Note: $[A]$ and $[C]$ are present only when new generalized coordinates are being added.

7. Write an end of file on S2L217, close the file, and return to the calling program.

The macro flow chart of this overlay is shown in figure 9.

The routines called are displayed in table 5.

I/O Devices of FORM13

FORM13's communication via files is displayed in figure 6.

FORM13 reads from the files:

GMASS	Generalized mass matrix (if not read from cards).
GSTIFF	Generalized stiffness matrix (if not read from cards).
S1L217	Matrices $[A]$ and $[C]$ (if control surface freedoms are being added) and the matrices$[M]$ and $[K]$ if they were read from cards by RSTRCT.

FORM13 writes onto the file:

S2L217	the matrices $[M_1]$, $[M_2]$, and$[M_3]$

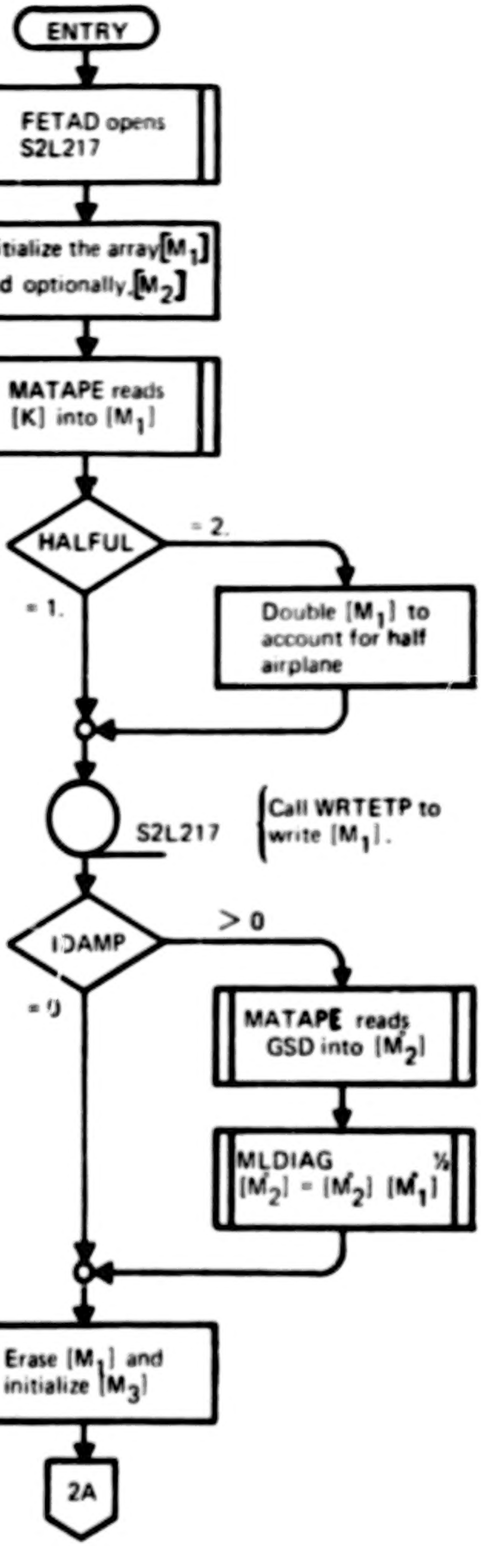

ENTRY
FETAD opens S2L217
Initialize the array [M1] and optionally [M2]
MATAPE reads [K] into [M1]
HALFUL
= 2.
= 1.
Double [M1] to account for half airplane
S2L217
Call WRTETP to write [M1].
IDAMP
> 0
= 0
MATAPE reads GSD into [M'2]
MLDIAG ½
[M'2] = [M2] [M'1]
Erase [M1] and initialize [M3]
2A

Figure 9. – Macro Flow Chart of Overlay (L217, 2, 3), FORM13

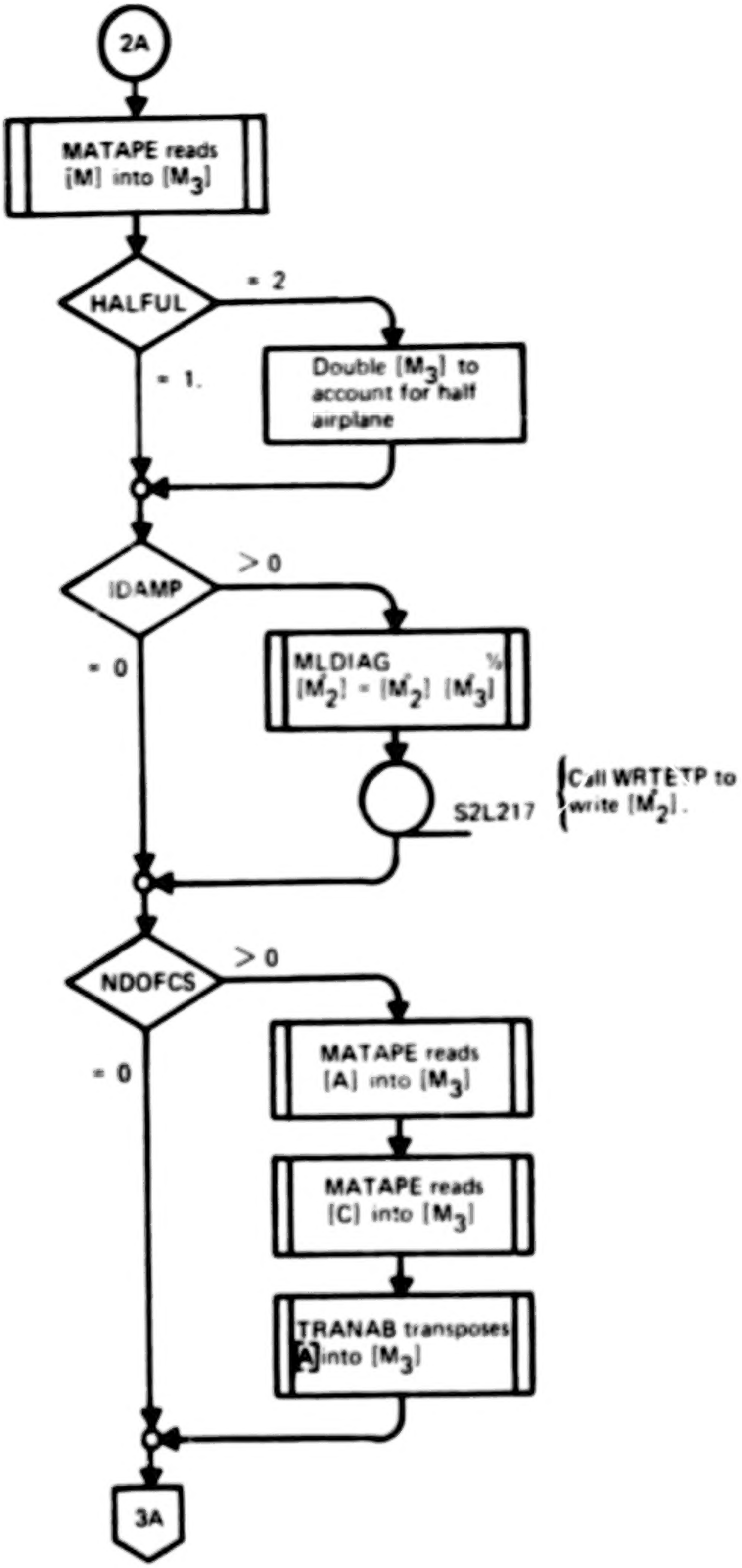

2A
MATAPE reads [M] into [M3]
HALFUL
= 2
= 1.
Double [M3] to account for half airplane
IDAMP
> 0
= 0
MLDIAG
½
[M'2] = [M'2] [M3]
S2L217
Call WRTETP to write [M'2].
NDOFCS
> 0
= 0
MATAPE reads [A] into [M3]
MATAPE reads [C] into [M3]
TRANAB transposes [A] into [M3]
3A

Figure 9. – (Continued)

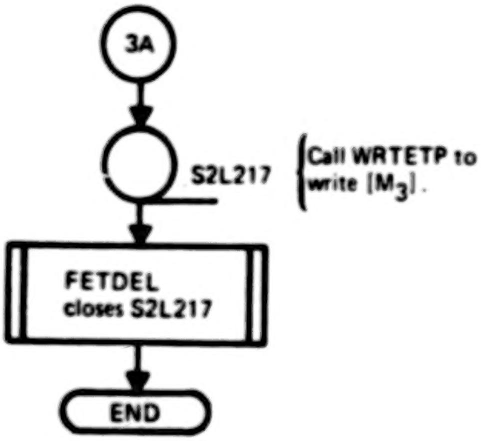


Figure 9. – (Concluded)

Table 5. – Routines Called by FORM13

```
OVERLAY(L217,2,3)

PROGRAM FORM13

-----------------------------------------


DELETR♦

FETAD♦

FETDEL♦

INITIR♦

MATAPE          {  FETAD♦

                   FETDEL♦

                   READTP♦

MLDIAG

PRINTM♦

SCLMLT♦

SETMFL

STARTR♦

TRANAB

WRTETP♦
```

♦ indicates a routine from the **DYLOFLEX** alternate subroutine library.

3.3 OVERLAY(L217,3,0), FLXAIC

Purpose of FLXAIC

FLXAIC generates aerodynamic force matrices and equations of motion coefficient matrices based upon the AIC matrices (A_{P_θ}) generated by FLEXSTAB (ref. 3).

Analytical Steps for FLXAIC

FLXAIC performs its task in the following steps:

1. Initialize the error count and print a message indicating that FLXAIC is being executed.

2. Call overlay (L217,3,1), FLXCDS, to read FLXAIC card input data.

3. Call overlay (L217,3,2), FLXGEO, to read geometry data from the FLEXSTAB file known as GDTAPE.

4. Call overlay (L217,3,3), FLXMOD, to interpolate for the modal data required by FLXAIC.

5. Call overlay (L217,3,4), FLXFRC, to calculate the aerodynamic forces at all force points.

6. Call overlay (L217,3,5), FLXODR, to sort the aerodynamic forces and prepare the output file known as EOMLOD.

7. Call overlay (L217,3,6), FLXEOM, to generate the aerodynamic equations of motion matrices and write them onto the file EOMTAP after the structural equations of motion matrices.

8. Print a message indicating that FLXAIC is finished and return to the main overlay, L217.

   If errors were detected in the secondary overlays, the program jumps to step 8.

The macro flow chart of this overlay is shown in figure 10.

The routines called are displayed in table 6.

The equations solved by FLXAIC are summarized as follows:

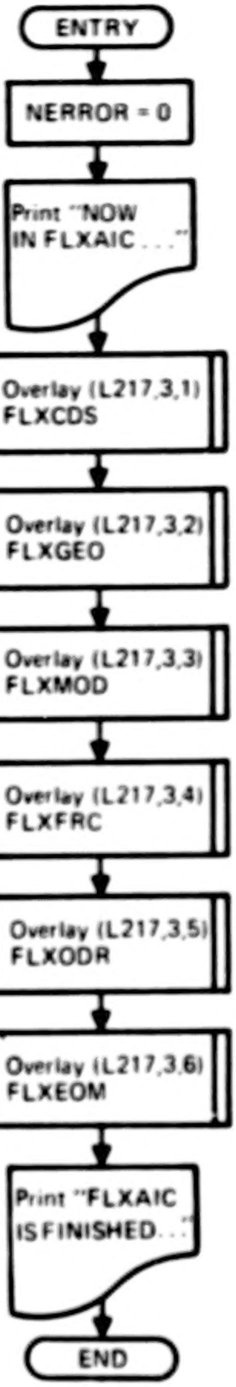

ENTRY
NERROR = 0
Print "NOW IN FLXAIC . . ."
Overlay (L217,3,1) FLXCDS
Overlay (L217,3,2) FLXGEO
Overlay (L217,3,3) FLXMOD
Overlay (L217,3,4) FLXFRC
Overlay (L217,3,5) FLXODR
Overlay (L217,3,6) FLXEOM
Print "FLXAIC IS FINISHED. . ."
END

Figure 10. – Macro Flow Chart of Overlay (L217,3,0), FLXAIC

Table 6. – Routines Called by FLXAIC

```
OVERLAY(L217,3,0)

PROGRAM FLXAIC

-----------------------------------------------


FLXCDS    -    OVERLAY(L217,3,1)

FLXGEO    -    OVERLAY(L217,3,2)

FLXMOD    -    OVERLAY(L217,3,3)

FLXPRC    -    OVERLAY(L217,3,4)

FLXODR    -    OVERLAY(L217,3,5)

FLXEOM    -    OVERLAY(L217,3,6)


FETAD*

FETDEL*
```

```
* indicates a routine from the DYLOFLEX
  alternate subroutine library
```

$$[F_1] = -q\,[F\overset{\circ}{A}C][\overset{\bullet}{\Sigma}][\overset{\circ}{A}][AIC][\phi'_{CP}]$$

$$[F_2] = -\frac{q}{V}[F\overset{\circ}{A}C][\overset{\bullet}{\Sigma}][\overset{\circ}{A}][AIC][\phi_{CP}]$$

$$[FG] = q\,[F\overset{\circ}{A}C][\overset{\bullet}{\Sigma}][\overset{\circ}{A}][AIC][\overset{\circ}{R}G][\overset{\bullet}{G}C]$$

$$[M_4] = -[\phi_{FP}]^T[\overset{\circ}{S}F][F_1]$$

$$[M_5] = -[\phi_{FP}]^T[\overset{\circ}{S}F][F_2]$$

$$[\tilde{\phi}] = [\phi_{FP}]^T[\overset{\circ}{S}F][FG]$$

An * indicates that the matrix product is not performed in the normal fashion.

For instance, $[\Sigma]$ is actually stored as NTOTF x four but in the matrix multiply, it acts like a matrix of size NAFP x NTOTF. The $[GC]$ is stored as NACP x one but it acts like a matrix NACP x NGCP in the matrix multiply. (See description of the file S1L217 just ahead of fig. 36.)

I/O Devices of FLXAIC

FLXAIC prints two messages on the output file; NOW IN FLXAIC...and FLXAIC IS FINISHED.... All other file communication in FLXAIC is performed by its secondary overlays. Figure 11 shows the files used in FLXAIC's secondary overlays.

In subsections 3.3.1 through 3.3.6 the matrices read from and written onto each file are listed. (See secs. 6.4 to 6.5 of vol. I, *Engineering and Usage*, for detailed descriptions of the format and content of the files used for external communication.) Section 3.6.3 of this volume contains the same information for L217 (EOM)'s temporary scratch files.

3.3.1 OVERLAY(L217,3,1), FLXCDS

Purpose of FLXCDS

FLXCDS reads the card input data directing the L217 (EOM) generation of equations of motion matrices from FLEXSTAB AIC matrices. (See card set 3.0 in vol. I of this document, *Engineering and Usage*.) Options, constants, and file names are stored in labelled common blocks for later use. The card data defining the correspondence between FLEXSTAB bodies (slender bodies and thin bodies), and the L215 (INTERP) modal interpolation surfaces are stored in the arrays {BODTAP} and {ICSTAB} and written onto the temporary storage file S1L217.

The macro flow chart of this overlay is shown in figure 12.

The routines called are displayed in table 7.

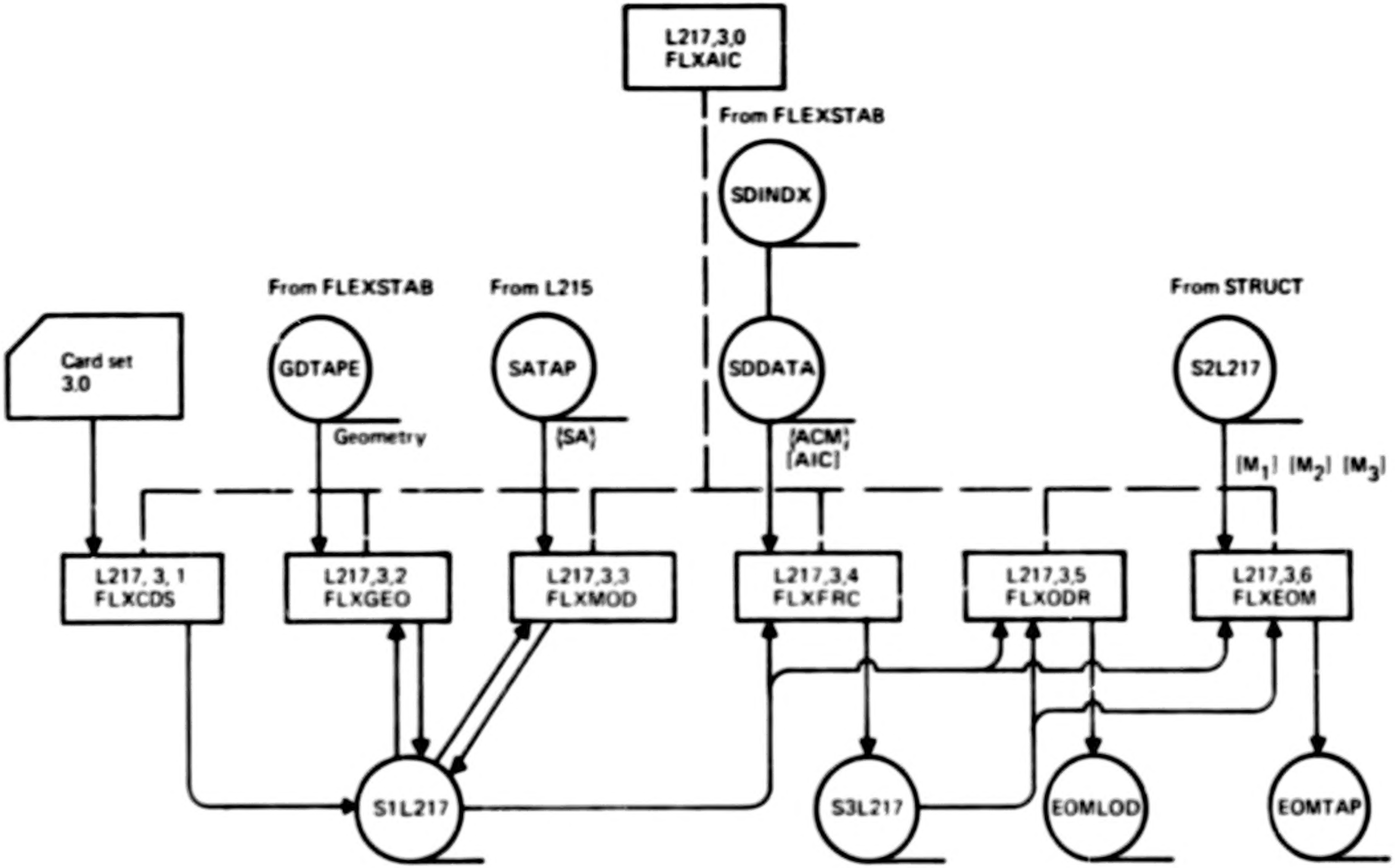


Figure 11. – Files Providing Input/Output to FLXAIC Overlays

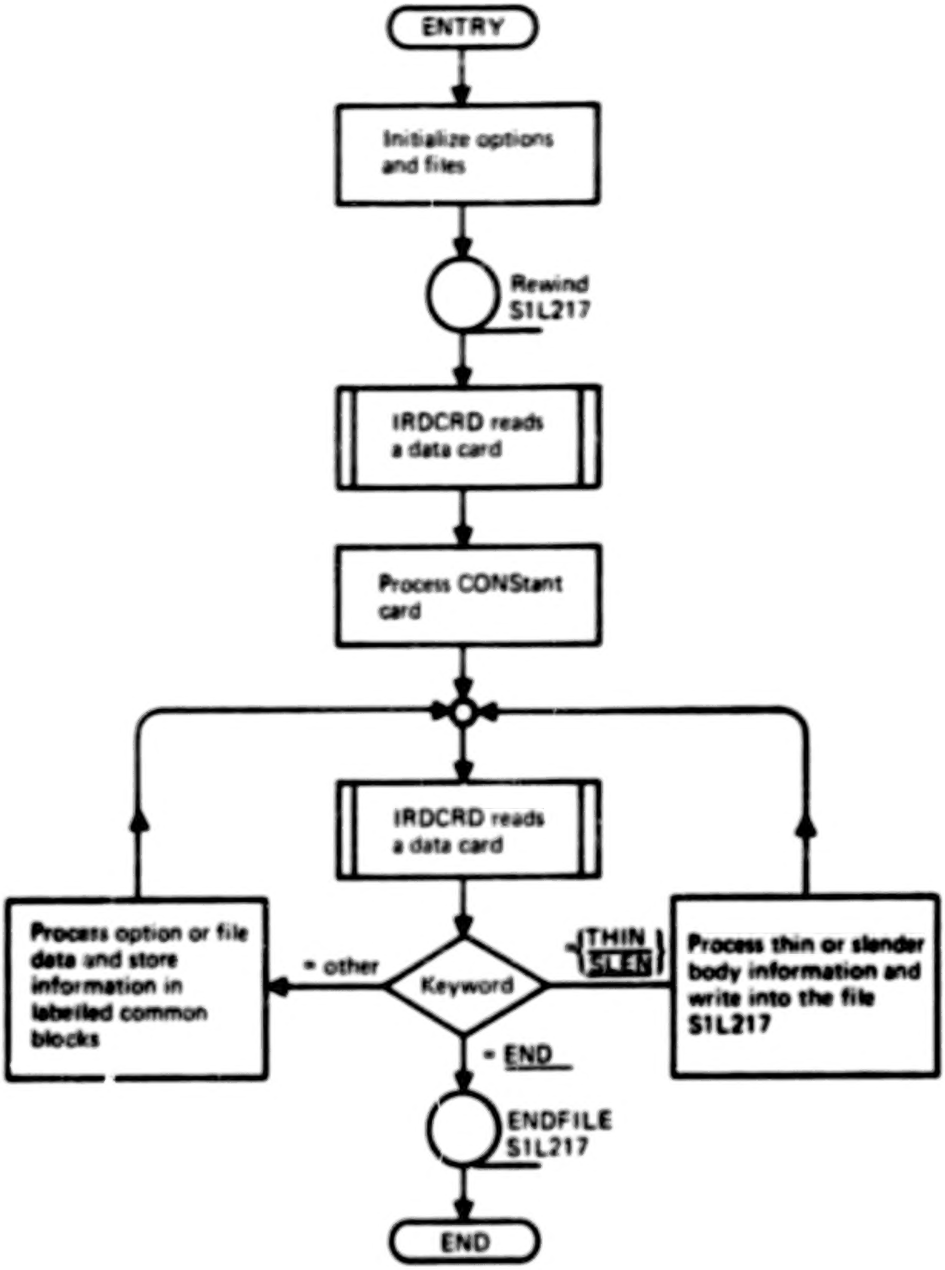

ENTRY
Initialize options and files
Rewind S1L217
IRDCRD reads a data card
Process CONStant card
IRDCRD reads a data card
Keyword
= other
= {THIN SLEN}
= END
Process option or file data and store information in labelled common blocks
Process thin or slender body information and write into the file S1L217
ENDFILE S1L217
END

Figure 12. – Macro Flow Chart of Overlay (L217, 3, 1), FLXCDS

Table 7. – Routines Called by FLXCDS

```
OVERLAY(L217,3,1)

PROGRAM FLXCDS

-------------------------------------------------


FNDKEY*

IPDCRD*

IPOL*

NAMFIL*

WRTETP*
```

* indicates a routine in the DYLOFLEX alternate subroutine library

I/O Devices Used

FLXCDS reads card set 3 from the input file and prints the card images on the output file with descriptive comments and any necessary diagnostics.

FLXCDS writes onto the file:

S1L217	Arrays {IBDTAB} and {ICSTAB} (see sec. 3.6.3 for contents)

3.2.2 OVERLAY(L217,3,2), FLXGEO

Purpose of FLXGEO

FLXGEO reads the FLEXSTAB geometry data from the file GDTAPE, combines it with the card input data saved on S1L217, and prepares the geometry data required thoughout FLXAIC. The matrices produced are written onto the file S1L217 (overwriting the arrays of card input data). See section 3.6.2 for a description of the file's contents and format.

The macro flow chart of this overlay is shown in figure 13.

The routines called are displayed in table 8.

I/O Devices of FLXGEO

FLXGEO reads from the files:

S1L217	Arrays {BODTAB} and {ICSTAB} written there by FLXCDS
GDTAPE	FLEXSTAB geometry data (see sec. 6.4.6 of vol. I)

FLXGEO writes onto the file:

S1L217	Geometry matrices and arrays directing the FLXAIC processing (see sec. 3.6.3 for content and format)

3.3.3 OVERLAY(L217,3,3), FLXMOD

Purpose of FLXMOD

FLXMOD uses the SA arrays read from the file SATAP (produced by L215 (INTERP)) to find the following matrices:

$[\phi_{CP}]$	Modal deflections at the aero control points (thin body box quarter chord and slender body segment midpoints)
$[\phi'_{CP}]$	Modal slopes at the aero control points
$[\phi_{FP}]$	Modal deflections at the aero force points

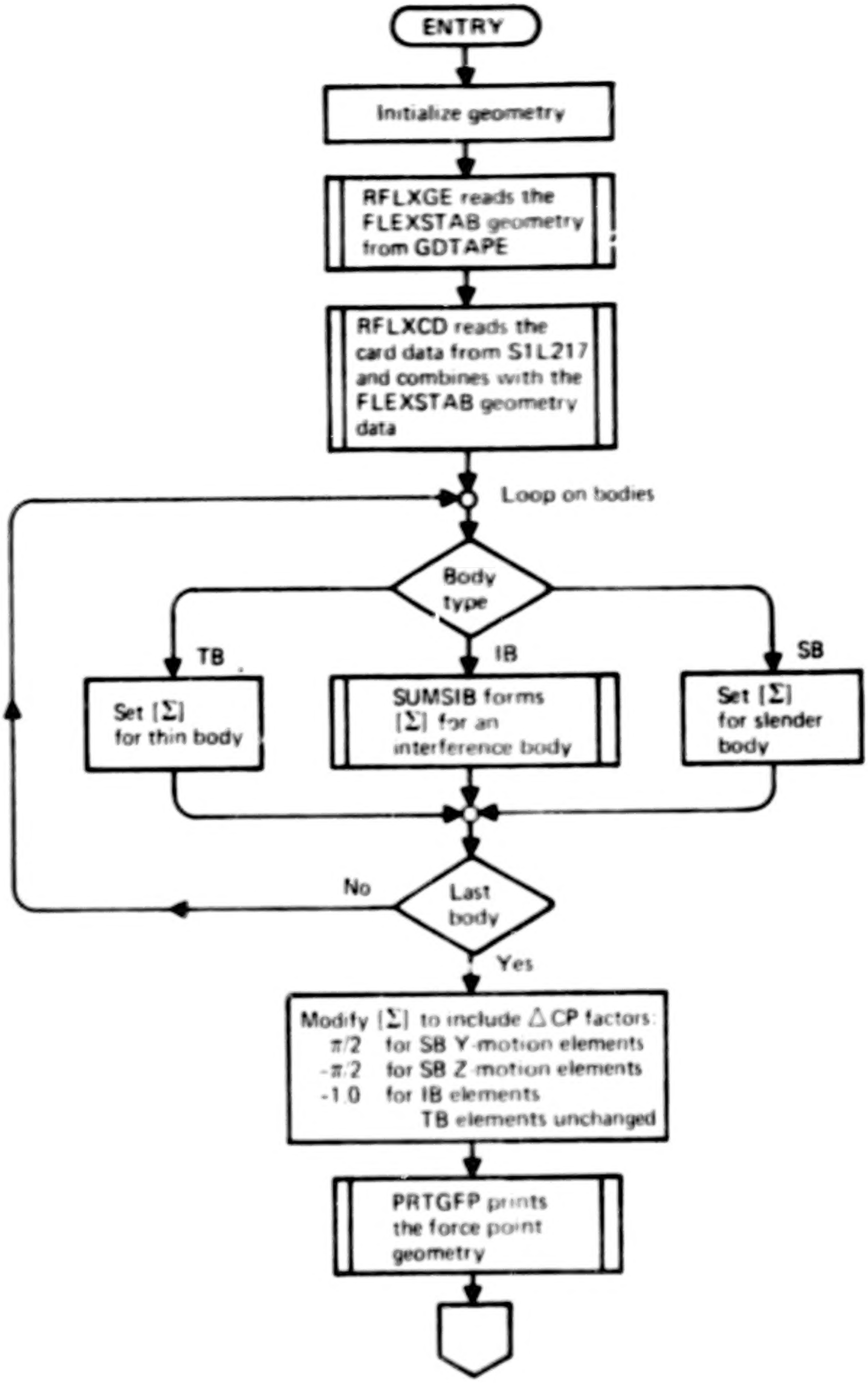

ENTRY
Initialize geometry
RFLXGE reads the FLEXSTAB geometry from GDTAPE
RFLXCD reads the card data from S1L217 and combines with the FLEXSTAB geometry data
Loop on bodies
Body type
TB
IB
SB
Set [Σ] for thin body
SUMSIB forms [Σ] for an interference body
Set [Σ] for slender body
No
Last body
Yes
Modify [Σ] to include ΔCP factors:
π/2 for SB Y-motion elements
-π/2 for SB Z-motion elements
-1.0 for IB elements
TB elements unchanged
PRTGFP prints the force point geometry

Figure 13. – Macro Flow Chart of Overlay (L217, 3, 2), FLXGEO

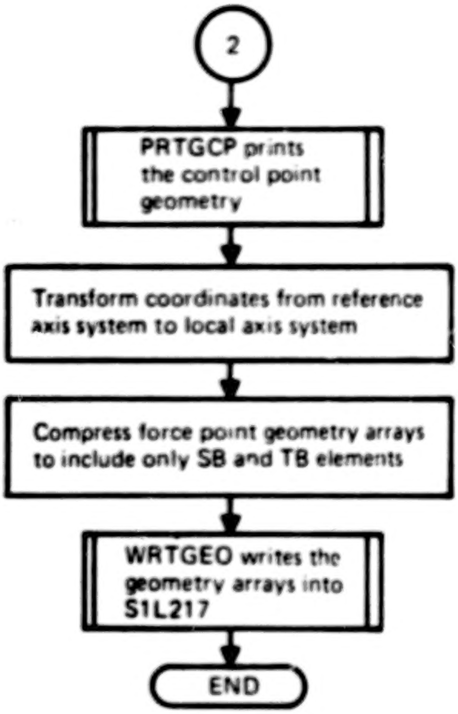

2
PRTGCP prints the control point geometry
Transform coordinates from reference axis system to local axis system
Compress force point geometry arrays to include only SB and TB elements
WRTGEO writes the geometry arrays into S1L217
END

Figure 13. – (Concluded)

Table 8. – Routines Called by FLXGEO

```
OVERLAY(L217,3,2)

PROGRAM FLXGEO

------------------------------------------


GTOLT*

PRTGCP

PRTGFP

RFLXCD       {    IRCL*

                  READTP*

RFLXGE       {    RETAD*

                  RETDEL*

                  RSF*

                  GZONES

SUMSIB

WRTGEO            WRTETP*
```

* indicates a routine in the **DYLOFLEX** alternate subroutine library.

The DYLOFLEX library routine AINTL is called to interpolate for the modal data using the SA array(s) from SATAP and the nodal coodinates read from S1L217.

The macro flow chart of this overlay is in figure 14.

The routines called are displayed in table 9.

I/O Devices of FLXMOD

FLXMOD reads from the files:

S1L217 The matrices

$$\left.\begin{array}{l}\{\mathrm{SURFTB}\}\\ \{\mathrm{IPNSRF}\}\\ \{\mathrm{X}\}\\ \{\mathrm{Y}\}\\ \{\mathrm{IPNSCP}\}\\ \{\mathrm{XCP}\}\\ \{\mathrm{YCP}\}\end{array}\right\}\ \text{all are described in section 3.6.3}$$

SATAP SA arrays from L215 (INTERP). (see vol. I of this document and ref. 5 for a description)

FLXMOD writes onto the file:

S1L217 Matrices $[\phi_{CP}]$, $[\phi'_{CP}]$, and $[\phi_{FP}]$

Note that if the number of modes is greater than 20 the matrices are partitioned and the trio is repeated as often as necessary to include all modes.

3.3.4 OVERLAY(L217,3,4), FLXFRC

Purpose of FLXFRC

FLXFRC generates the aerodynamic forces matrices $[F_1]$, $[F_2]$, and $[FG]$ where:

$$[F_1] = -q\,[F\mathring{A}C][\overset{\bullet}{\Sigma}][\mathring{A}][AIC][\phi'_{CP}]$$

$$[F_2] = -\frac{q}{v}[F\mathring{A}C][\overset{\bullet}{\Sigma}][\mathring{A}][AIC][\phi_{CP}]$$

$$[FG] = q\,[F\mathring{A}C][\overset{\bullet}{\Sigma}][\mathring{A}][AIC][R\mathring{G}][G\overset{\bullet}{C}]$$

If the number of modes exceeds 20, the matrices $[\phi_{CP}]$ and $[\phi'_{CP}]$ are read in partitions, and the matrices $[F_1]$ and $[F_2]$ are generated in partitions with the same number of columns.

The • above the matrices $[\Sigma]$ and $[GC]$ indicates that the operation performed is not a normal matrix multiply. Both matrices are described in section 3.6.3 with the file S1L217.

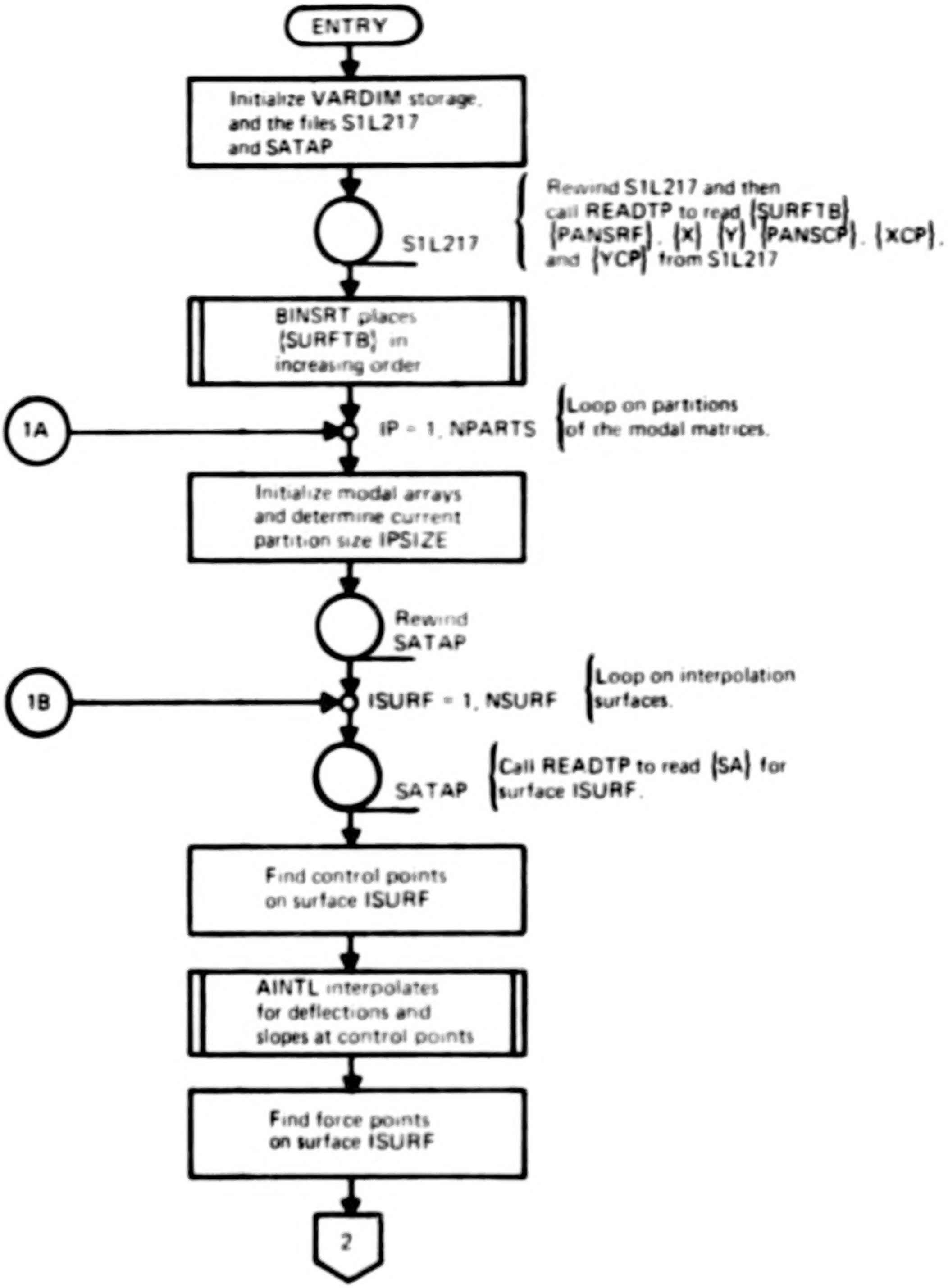

ENTRY
Initialize VARDIM storage, and the files S1L217 and SATAP
S1L217
Rewind S1L217 and then call READTP to read {SURFTB}, {PANSRF}, {X}, {Y}, {PANSCP}, {XCP}, and {YCP} from S1L217
BINSRT places {SURFTB} in increasing order
1A
IP = 1, NPARTS
Loop on partitions of the modal matrices.
Initialize modal arrays and determine current partition size IPSIZE
Rewind SATAP
1B
ISURF = 1, NSURF
Loop on interpolation surfaces.
SATAP
Call READTP to read {SA} for surface ISURF.
Find control points on surface ISURF
AINTL interpolates for deflections and slopes at control points
Find force points on surface ISURF
2

Figure 14. – Macro Flow Chart of Overlay (L217, 3, 3), FLXMOD

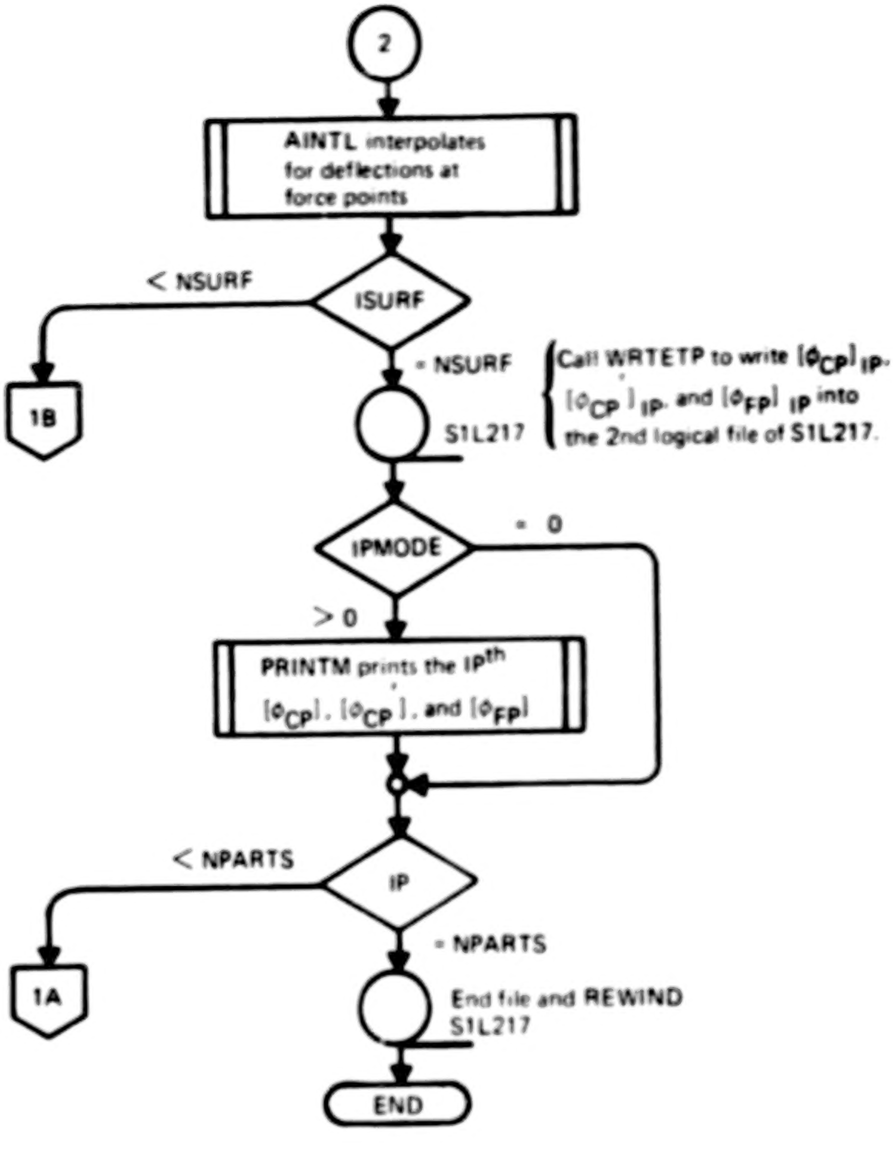

2
AINTL interpolates for deflections at force points
ISURF
< NSURF
1B
= NSURF
S1L217
Call WRTETP to write $[\phi_{CP}]_{IP}$, $[\phi'_{CP}]_{IP}$, and $[\phi_{FP}]_{IP}$ into the 2nd logical file of S1L217.
IPMODE
= 0
> 0
PRINTM prints the IPth $[\phi_{CP}]$, $[\phi'_{CP}]$, and $[\phi_{FP}]$
IP
< NPARTS
1A
= NPARTS
End file and REWIND S1L217
END

Figure 14. – (Concluded)

Table 9. – Routines Called by FLXMOD

```
OVERLAY(L217,3,3)

PROGRAM FLXMOD

-----------------------------------------


AINTL*

BINSRT

FETAD*

FETDEL*

INITIR*

PRINTM*

READTP*

SETMFL

STARTP*

WRTETP*
```

* indicates a routine in the DYLOFLEX alternate subroutine library.

The macro flow chart of this overlay is shown in figure 15.

The routines called are displayed in table 10.

I/O Devices of FLXFRC

FLXFRC reads from the files:

S1L217 Matrices $[\mathring{A}]$, $[\Sigma]$, $[F\mathring{A}C]$, $[GC]$, $[\mathring{R}G]$, $[\phi_{CP}]$, $[\phi'_{CP}]$, and $[\phi_{FP}]$
(See sec. 3.6.3 for a description.)

SDINDX Table describing the FLEXSTAB aerodynamic data on SDDATA

SDDATA Matrix AIC by rows

The AIC matrix read is known inside FLEXSTAB as Ap_{ij} . (See sec. 6.4 of vol. I and ref. 3 for a complete description of both SDINDX and SDDATA.)

FLXFRC writes onto the file:

S3L217 the matrices

$[F_1]$ (partitioned if necessary)
$[F_2]$ (partitioned if necessary)
$[FG]$ (by columns)

3.3.5 OVERLAY(L217,3,5), FLXODR

Purpose of FLXODR

FLXODR sorts the aerodynamic force matrices according to the interpolation surface number corresponding with each element. The resulting surface force matrices are written onto the file EOMLOD.

The macro flow chart of this overlay is shown in figure 16.

The routines called are displayed in table 11.

I/O Devices of FLXODR

FLXODR reads from the files:

S1L217 The matrices

$$\left.\begin{array}{l}\{\mathrm{SURFTB}\}\\ \{\mathrm{IPNSRF}\}\\ \{\mathrm{X}\}\\ \{\mathrm{Y}\}\\ \{\mathrm{AREA}\}\end{array}\right\} \quad \text{See section 3.6.3}$$

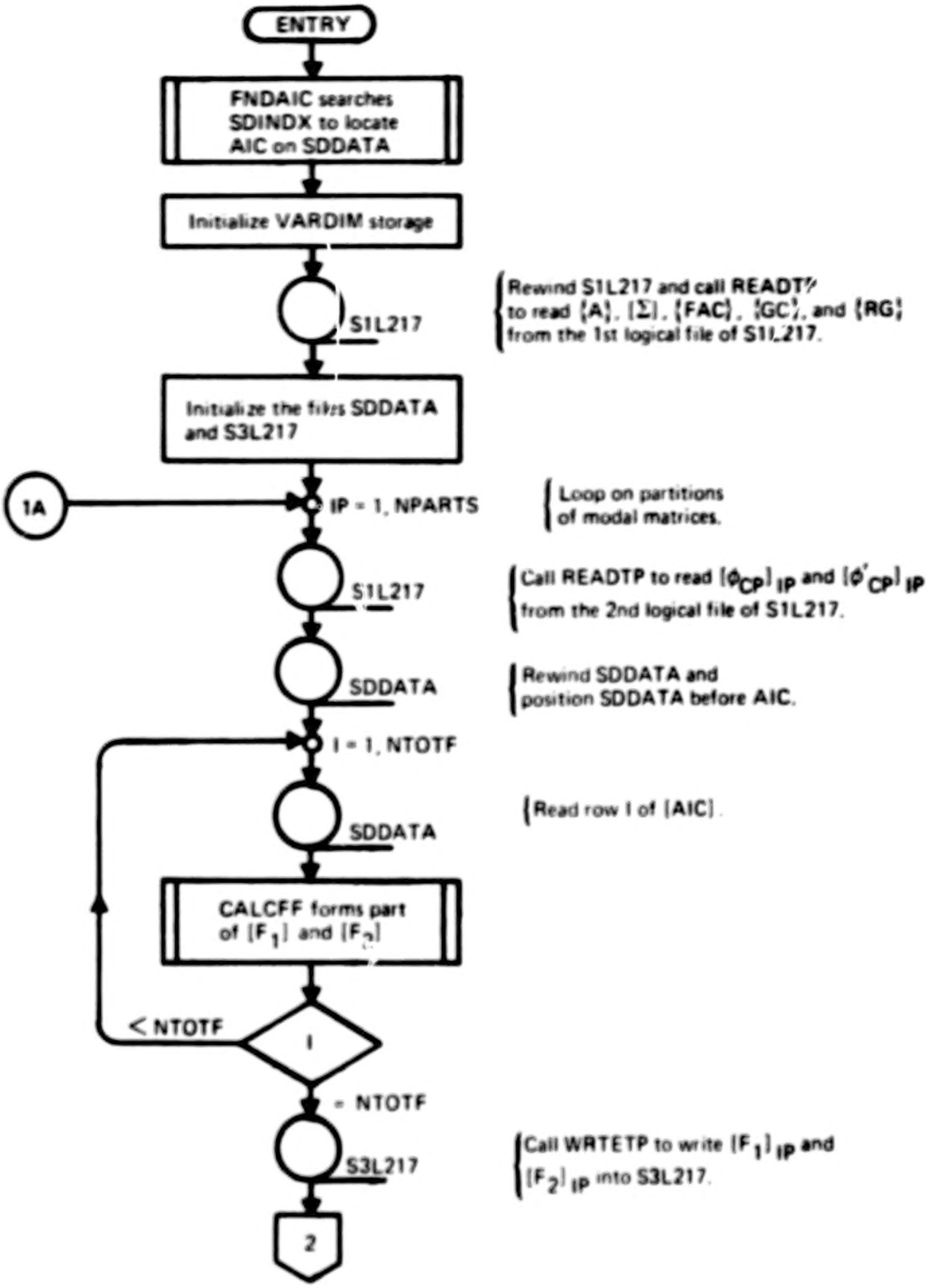

ENTRY
FNDAIC searches SDINDX to locate AIC on SDDATA
Initialize VARDIM storage
S1L217
Rewind S1L217 and call READTP to read {A}, [Σ], {FAC}, {GC}, and {RG} from the 1st logical file of S1L217.
Initialize the files SDDATA and S3L217
1A
IP = 1, NPARTS
Loop on partitions of modal matrices.
S1L217
Call READTP to read $[\phi_{CP}]_{IP}$ and $[\phi'_{CP}]_{IP}$ from the 2nd logical file of S1L217.
SDDATA
Rewind SDDATA and position SDDATA before AIC.
I = 1, NTOTF
SDDATA
Read row I of [AIC].
CALCFF forms part of $[F_1]$ and $[F_2]$
< NTOTF
I
= NTOTF
S3L217
Call WRTETP to write $[F_1]_{IP}$ and $[F_2]_{IP}$ into S3L217.
2

Figure 15. – Macro Flow Chart of Overlay (L217 3, 4), FLXFRC

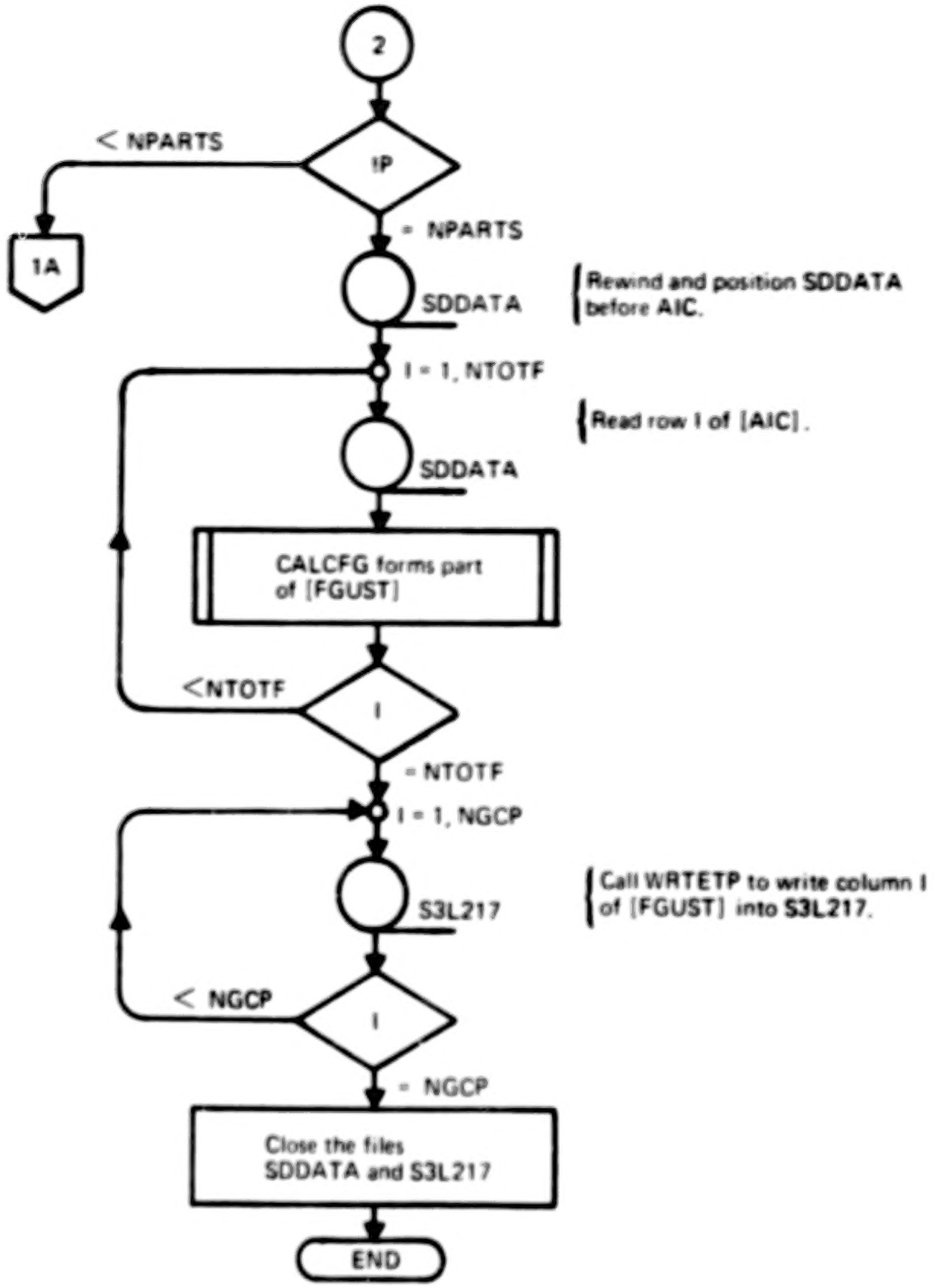

2
IP
< NPARTS
1A
= NPARTS
SDDATA
Rewind and position SDDATA before AIC.
I = 1, NTOTF
Read row I of [AIC].
SDDATA
CALCFG forms part of [FGUST]
<NTOTF
I
= NTOTF
I = 1, NGCP
S3L217
Call WRTETP to write column I of [FGUST] into S3L217.
< NGCP
I
= NGCP
Close the files SDDATA and S3L217
END

Figure 15. – (Concluded)

Table 10. – Routines Called by FLXFRC

```
OVERLAY(L217,3,4)

PROGRAM FLXFRC

-----------------------------------------------


CALCFF          VIP*

CALCFG

DELETR*

FETAD*

FETDEL*

FNDAIC

FSF*

FSR*

INITIR*

PRINTM*

READTP*

STARTR*

WRTETP*
```

* indicates a routine from the DYLOFLEX alternate subroutine library.

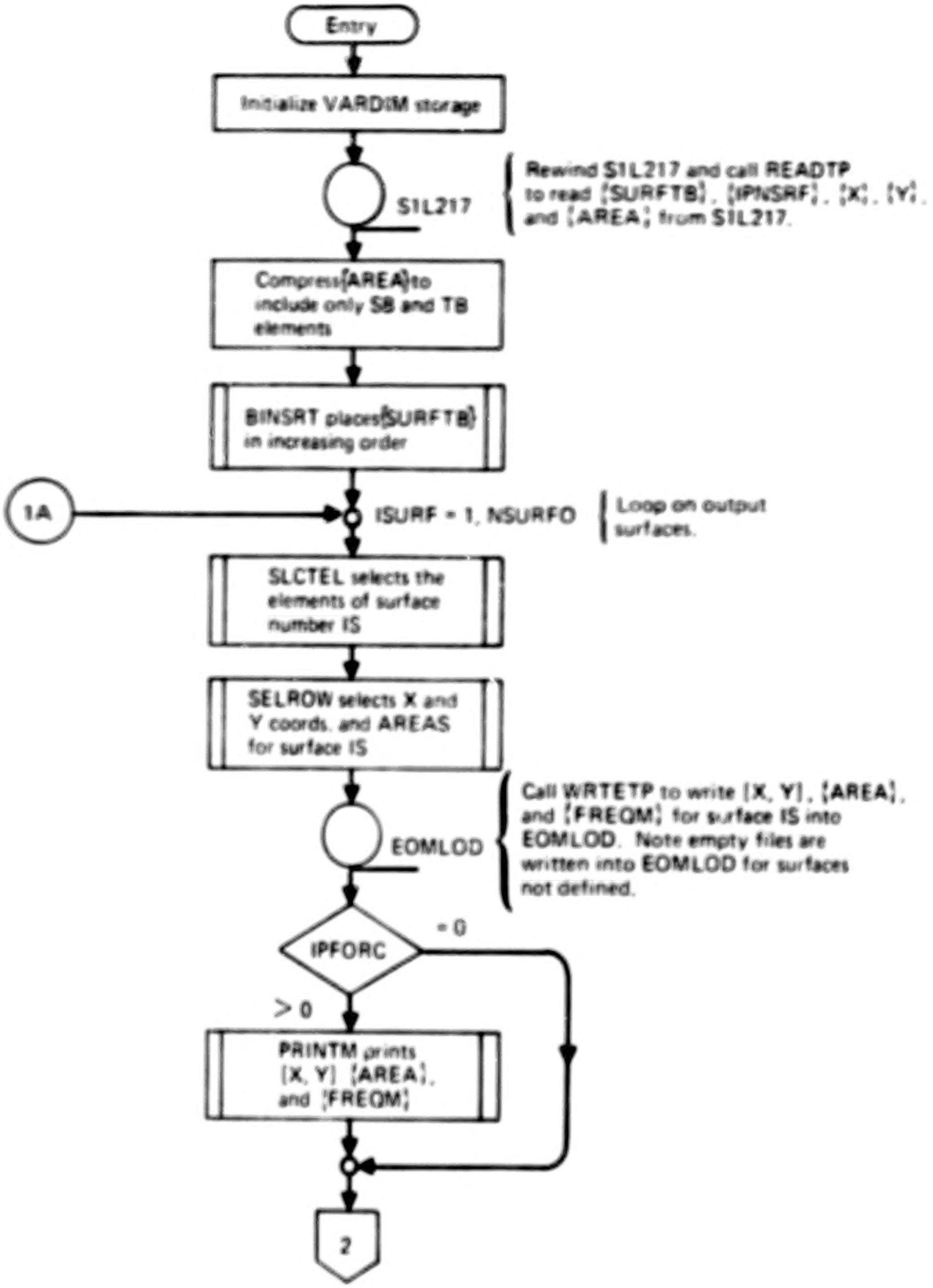

Entry
Initialize VARDIM storage
S1L217
Rewind S1L217 and call READTP to read {SURFTB}, {IPNSRF}, {X}, {Y}, and {AREA} from S1L217.
Compress {AREA} to include only SB and TB elements
BINSRT places {SURFTB} in increasing order
1A
ISURF = 1, NSURFO
Loop on output surfaces.
SLCTEL selects the elements of surface number IS
SELROW selects X and Y coords. and AREAS for surface IS
EOMLOD
Call WRTETP to write [X, Y], {AREA}, and {FREQM} for surface IS into EOMLOD. Note empty files are written into EOMLOD for surfaces not defined.
IPFORC
= 0
> 0
PRINTM prints [X, Y] {AREA}, and {FREQM}
2

Figure 16. – Macro Flow Chart of Overlay (L217, 3, 5), FLXODR

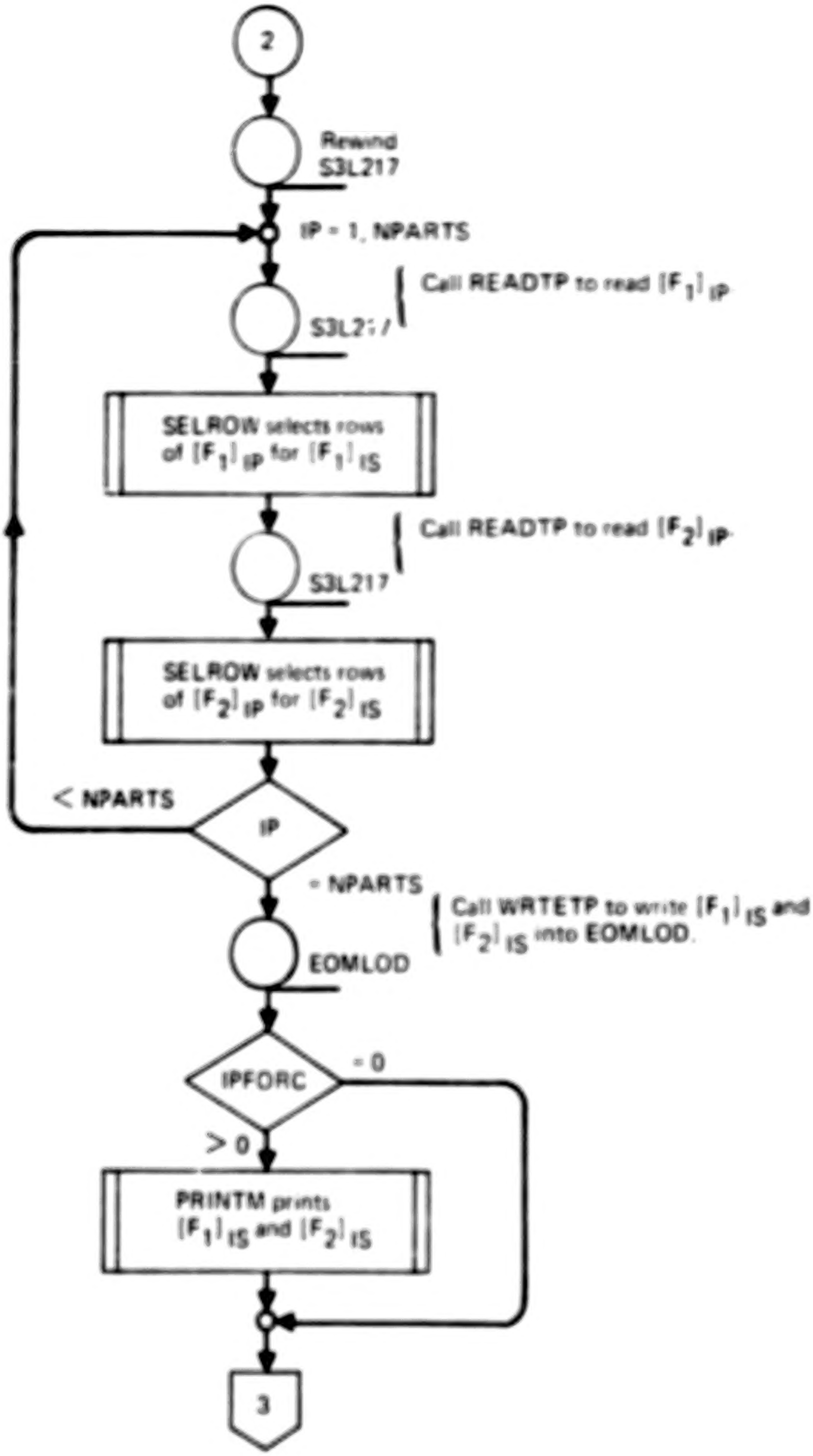

2
Rewind
S3L217
IP = 1, NPARTS
Call READTP to read $[F_1]_{IP}$
S3L217
SELROW selects rows of $[F_1]_{IP}$ for $[F_1]_{IS}$
Call READTP to read $[F_2]_{IP}$.
S3L217
SELROW selects rows of $[F_2]_{IP}$ for $[F_2]_{IS}$
< NPARTS
IP
= NPARTS
Call WRTETP to write $[F_1]_{IS}$ and $[F_2]_{IS}$ into EOMLOD.
EOMLOD
IPFORC
= 0
> 0
PRINTM prints $[F_1]_{IS}$ and $[F_2]_{IS}$
3

Figure 16. – (Continued)

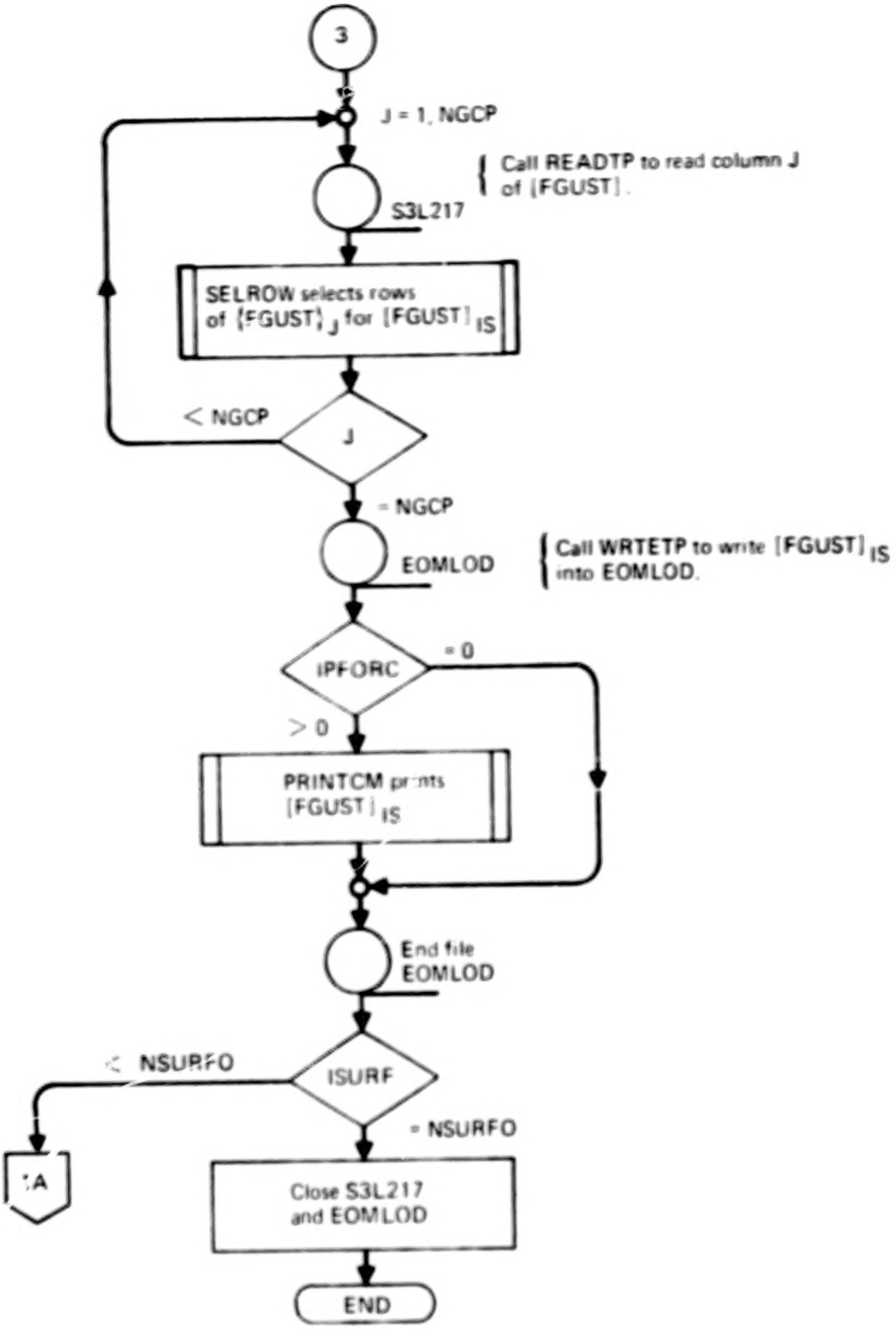


Figure 16. — (Concluded)

Table 11. – Routines Called by FLXODR

```
OVERLAY(L217,3,5)

PROGRAM FLXODR

-------------------------------------------


BINSRT

DELETR+

FETAD+

FETDEL+

INITIR+

PRINTM+

PRNTCM+

READTP+

SELROW

SETMFL

SLCTEL

STARTR+

WRTETP+
```

```
+ indicates a routine in the DYLOFLEX
  alternate subroutine library
```

S3L217 The matrices

$[F_1]$ (partitioned if necessary)
$[F_2]$ (partitioned if necessary)
$[FG]$ (by columns)

FLXODR writes onto the file:

EOMLOD The following matrices for each surface in a separate logical file

$$\left.\begin{array}{l}[X,Y]\\ \{AREA\}\\ [F_1]\\ [F_2]\\ [FG]\end{array}\right\}\quad\text{See section 6.5.2 of volume I}$$

3.3.6 OVERLAY(L217,3,6), FLXEOM

Purpose of FLXEOM

FLXEOM generates the file EOMTAP containing the equations of motion matrices $[M_1]$, $[M_2]$, $[M_3]$, $[M_4]$, $[M_5]$, and $[\tilde{\phi}]$. The structural equations of motion ($[M_1]$, $[M_2]$, and $[M_3]$) are copied from S2L217 where they were stored by **STRUCT**. The aerodynamic equations of motion are formed

$$[M_4] = -[\phi_{FP}]^T[\dot{S}F][F_1]$$

$$[M_5] = -[\phi_{FP}]^T[\dot{S}F][F_2]$$

$$[\tilde{\phi}] = [\phi_{FP}]^T[\dot{S}F][FG]$$

using the $[F_1]$, $[F_2]$, and $[FG]$ stored on S3L217 by **FLXFRC**.

The macro flow chart of this overlay is shown in figure 17.

The routines called are displayed in table 12.

I/O Devices of FLXEOM

FLXEOM reads from the files:

S1L217 The matrices

$[\dot{S}F]$ from the first logical file
$[\phi_{FP}]$ from the second logical file

S2L217 The matrices

$[M_1]$
$[M_2]$ (optional)
$[M_3]$

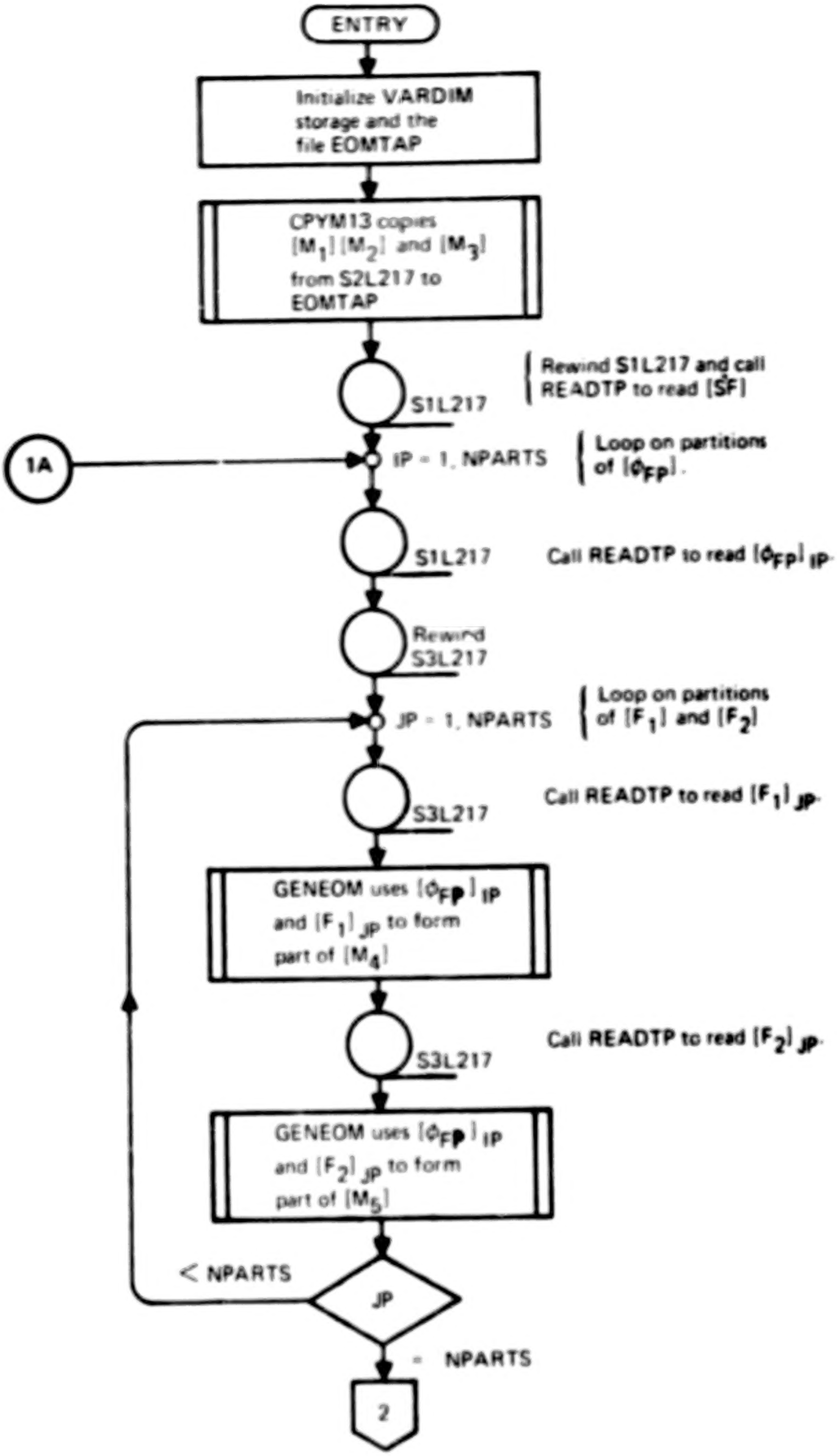

ENTRY
Initialize VARDIM storage and the file EOMTAP
CPYM13 copies $[M_1]$ $[M_2]$ and $[M_3]$ from S2L217 to EOMTAP
S1L217
Rewind S1L217 and call READTP to read $[\hat{S}F]$
1A
IP = 1, NPARTS
Loop on partitions of $[\phi_{FP}]$.
S1L217
Call READTP to read $[\phi_{FP}]_{IP}$.
Rewind S3L217
JP = 1, NPARTS
Loop on partitions of $[F_1]$ and $[F_2]$
S3L217
Call READTP to read $[F_1]_{JP}$.
GENEOM uses $[\phi_{FP}]_{IP}$ and $[F_1]_{JP}$ to form part of $[M_4]$
S3L217
Call READTP to read $[F_2]_{JP}$.
GENEOM uses $[\phi_{FP}]_{IP}$ and $[F_2]_{JP}$ to form part of $[M_5]$
< NPARTS
JP
= NPARTS
2

Figure 17. – Macro Flow Chart of Overlay (L217, 3, 6), FLXEOM

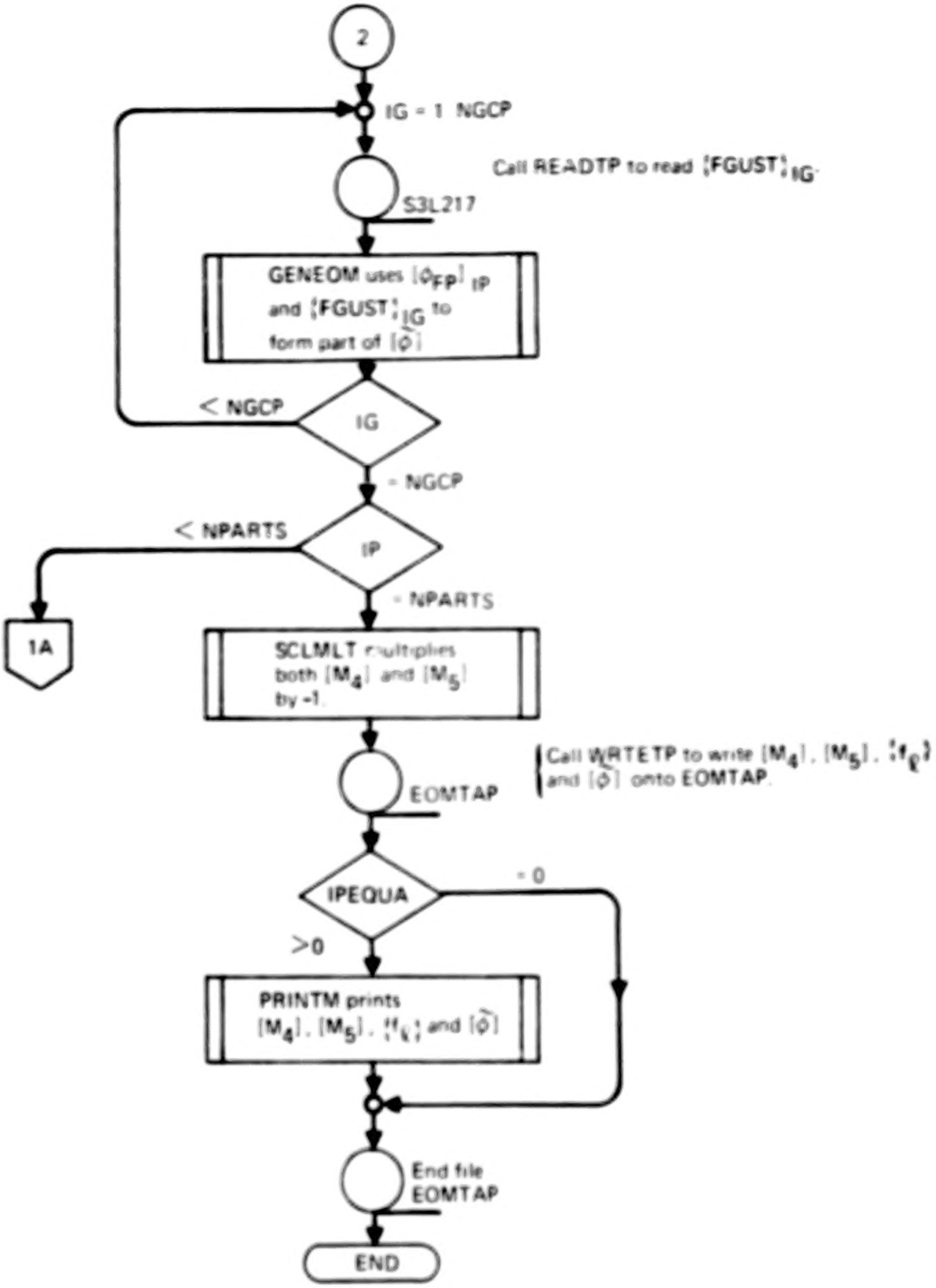

2
IG = 1 NGCP
Call READTP to read {FGUST}IG.
S3L217
GENEOM uses [φFP] IP and {FGUST}IG to form part of [φ̃]
< NGCP
IG
= NGCP
< NPARTS
IP
= NPARTS
1A
SCLMLT multiplies both [M4] and [M5] by -1.
Call WRTETP to write [M4], [M5], {fℓ} and [φ̃] onto EOMTAP.
EOMTAP
= 0
IPEQUA
>0
PRINTM prints [M4], [M5], {fℓ} and [φ̃]
End file EOMTAP
END

Figure 17. – (Concluded)

Table 12. – Routines Called by FLXEOM

```
OVERLAY(L217,3,6)

PROGRAM FLXEOM

-----------------------------------------

CPYM13  { FETAD*
        | FETDEL*
        | PRINTM*
        | READTP*
        | WRTETP*
DELETR*
FETAD*
FETDEL*
GENEOM    VIP*
INITIP*
PRINTM*
PRNTCM*
READTP*
SCLMLT
SETMFL
STARTR*
WRTETP*

* indicates a routine in the DYLOFLEX
  alternate subroutine library
```

S3L217 The matrices

$[F_1]$	(partitioned if necessary)
$[F_2]$	(partitioned if necessary)
$[FG]$	(by columns)

See section 3.6.3 for a detailed description of S1L217, S2L217, and S3L217.

FLXEOM writes the following matrices onto the file EOMTAP:

$$\left.\begin{array}{l}\{\mathbf{HEADER}\}\\ [\mathbf{M}_1]\\ [\mathbf{M}_2]\\ [\mathbf{M}_3]\\ \{\mathbf{FREQM}\}\\ [\mathbf{M}_4]\\ [\mathbf{M}_5]\\ \{\mathbf{f}_\ell\}\\ [\tilde{\Phi}]\end{array}\right\}\quad\begin{array}{l}\text{(optional)}\\ \text{See section 6.5.2}\\ \text{of volume I}\end{array}$$

3.4 OVERLAY(L217,4,0), DLAIC

Purpose of DLAIC

DLAIC generates aerodynamic force matrices and equations of motion coefficient matrices based upon the L216 (DUBFLX)(ref. 4) Doublet Lattice AIC matrices.

Analytical Steps of DLAIC

DLAIC performs its task in the following steps:

1. Print the message NOW IN DLAIC TO..., initialize the count of errors, and initialize the scratch file named S1L217.

2. Call overlay (L217,4,1), DLACDS, to read card set 3.0.

3. Call overlay (L217,4,2), DLAGEO, to read the Doublet Lattice geometry data from NGETP, combine it with card input data from DLACDS, and prepare geometry arrays needed in steps 4 through 10.

4. Call overlay (L217,4,3), DLAMOD, to interpolate for mode shapes at force and control points.

   Repeat steps 5 through 8 for each frequency at which the aerodynamics are defined.

5. Call overlay (L217,4,4), CPANDW, to generate the arrays $[CP_{SB}]$, $[CPG_{SB}]$, $[W_{TB}]$, and $[WG_{TB}]$.

6. Call overlay (L217,4,5), FORMWS, to generate the arrays $[W]$ and $[WG]$.

7. Call overlay (L217,4,6), SOLVDW, to solve the equation for $[\Delta cp]$, $[D][\Delta cp] = [W/WG]$.

8. Call overlay (L217,4,7), DLAFRC, to generate the arrays $[FR]$ and $[FG]$.

9. Call overlay (L217,4,10_8), DLAODR, to sort the aerodynamic forces per surface and write them onto the file EOMLOD.

10. Call overlay (L217,4,11_8), DLAEOM, to prepare $[M_4]$, $[M_5]$, and $[\tilde{\phi}]$ and generate the file EOMTAP.

11. Return to the calling program.

The macro flow chart of this overlay is shown in figure 18.

The routines called are displayed in table 13.

The equations solved by DLAIC are summarized as follows:

$$[FR] = [F\overset{\circ}{A}C]\left[\begin{array}{c} [0] \\ \hdashline q[\overset{\circ}{A}_{SB}][CP_{SB}] \end{array}\right] + q[\overset{\bullet}{\Sigma}][A_{TB/IB}][D]^{-1}[W_{AUG}]$$

$$\text{where:}\quad [W_{AUG}] = -\left[\begin{array}{c:c} [\phi'_{CP}]_{TB} & i\omega[\phi_{CP}]_{TB} \\ \hdashline [0] & [0] \end{array}\right] + [F][CP_{SB}]$$

$$\text{and:}\quad [CP_{SB}] = 2\pi\left[[\overset{\circ\prime}{R}] + \frac{i\omega}{2v}[\overset{\circ}{R}]\right]\left[[\dot{\phi}_{CP}]_{SB} + \frac{i\omega}{v}[\phi_{CP}]_{SB}\right] + \pi[\overset{\bullet}{R}]\left[[\phi''_{CP}]_{SB} + \frac{i\omega}{v}[\phi'_{CP}]_{SB}\right]$$

$$[FG] = [F\overset{\circ}{A}C]\left[\begin{array}{c} [0] \\ \hdashline q[\overset{\circ}{A}_{SB}]\ [CPG_{SB}] \end{array}\right] + q[\overset{\bullet}{\Sigma}]\ [\overset{\circ}{A}_{TB/IB}]\ [D]^{-1}\ [WG_{AUG}]$$

$$\text{where:}\quad [WG_{AUG}] = \frac{1}{v}\begin{bmatrix} [\overset{\circ}{R}G]_{TB} & \\ & [0] \end{bmatrix}\begin{bmatrix} [GC]_{TB} & \\ & [0] \end{bmatrix} + [F]\ [CPG_{SB}]$$

$$\text{and:}\quad [CPG_{SB}] = -\frac{2\pi}{v}\left[[\overset{\circ\prime}{R}]\ [\overset{\bullet}{GC}_{SB}]\right]$$

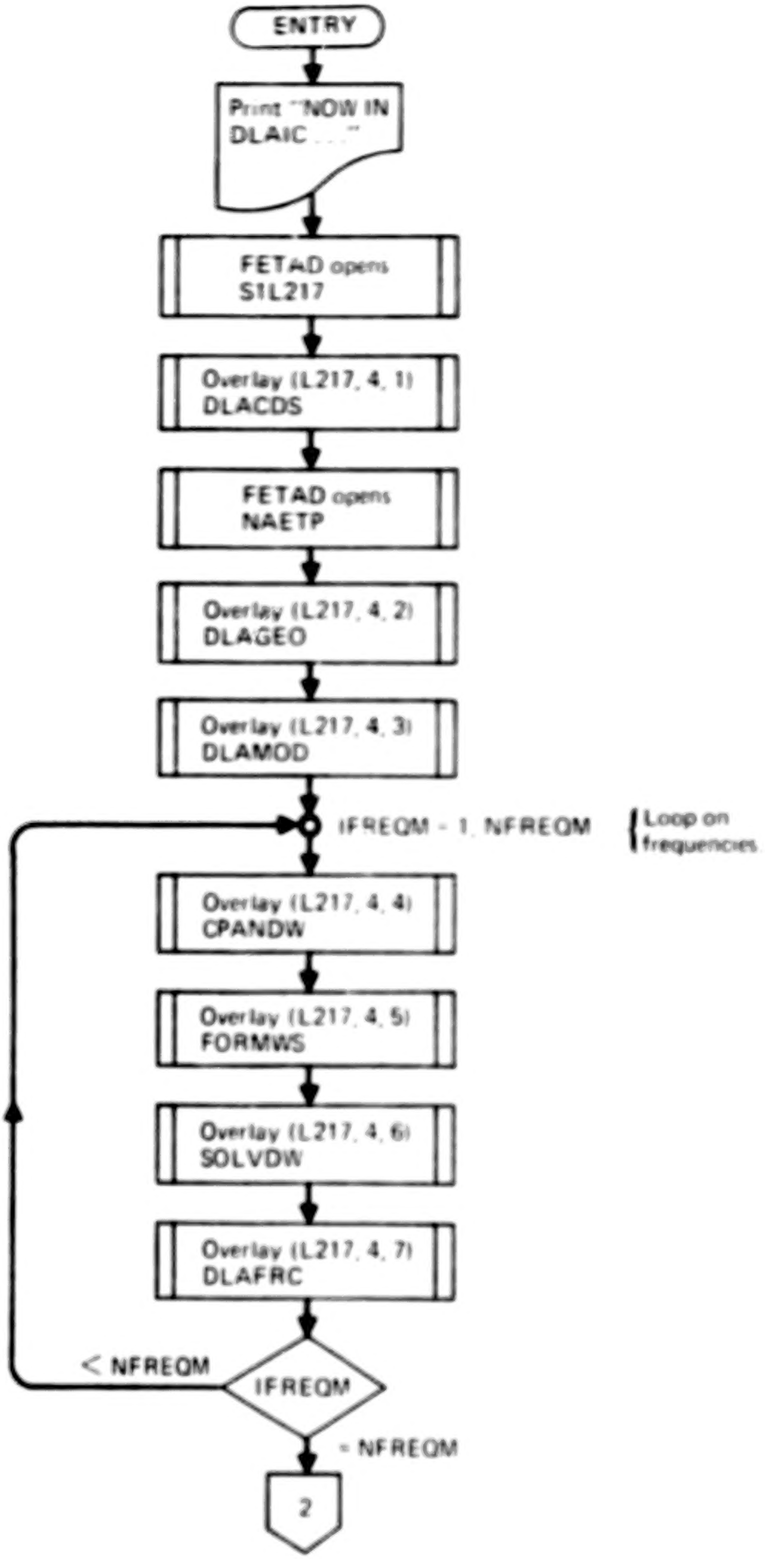

ENTRY
Print "NOW IN DLAIC . . ."
FETAD opens S1L217
Overlay (L217, 4, 1) DLACDS
FETAD opens NAETP
Overlay (L217, 4, 2) DLAGEO
Overlay (L217, 4, 3) DLAMOD
IFREQM = 1, NFREQM
Loop on frequencies
Overlay (L217, 4, 4) CPANDW
Overlay (L217, 4, 5) FORMWS
Overlay (L217, 4, 6) SOLVDW
Overlay (L217, 4, 7) DLAFRC
< NFREQM
IFREQM
= NFREQM
2

Figure 18. – Macro Flow Chart of Overlay (L217, 4, 0), DLAIC

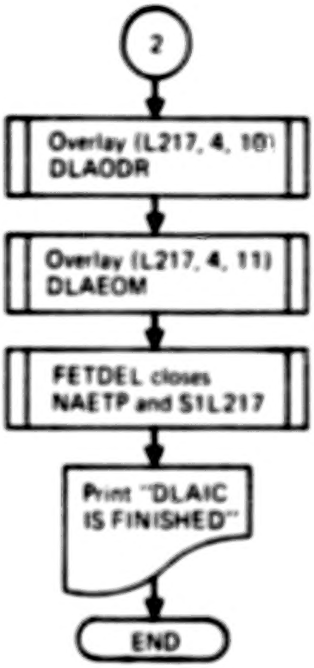


Figure 18. – (Concluded)

Table 13. – Routines Called by DLAIC

```
OVERLAY(L217,4,0)

PROGRAM DLAIC

----------------------------------------


CPANDW    -    OVERLAY(L217,4,4)

DLACDS    -    OVERLAY(L217,4,1)

DLAEOM    -    OVERLAY(L217,4,11)

DLAFRC    -    OVERLAY(L217,4,7)

DLAGEO    -    OVERLAY(L217,4,2)

DLAMOD    -    OVERLAY(L217,4,3)

DLAODR    -    OVERLAY(L217,4,10)

FORMWS    -    OVERLAY(L217,4,5)

SOLVDW    -    OVERLAY(L217,4,6)

FETAD*

FETDEL*
```

```
* indicates routines from the DYLOFLEX
  alternate subroutine library
```

$$[F_1] = [FR]_{\text{Real}}$$

$$[F_2] = [FR]_{\text{Imaginary}}$$

$$[QR] = [\phi_{FP}]^{T}_{TB/SB}\,[\dot{S}F]\,[FR]$$

$$[M_4] = -[QR]_{\text{Real}}$$

$$[M_5] = -\frac{1}{\omega}[QR]_{\text{Imaginary}}$$

$$[\tilde{\phi}] = [\phi_{FP}]^{T}_{TB/SB}\,[\dot{S}F]\,[FG]$$

Note: For a quasi-steady solution, the two expressions of $\frac{i\omega}{v}$ in $[CP_{SB}]$ become simply $\frac{i}{v}$.

I/O Devices of DLAIC

DLAIC prints two messages on the output file; NOW IN DLAIC..., and DLAIC IS FINISHED.... All other file communication in DLAIC is performed by its secondary overlays. Figure 18 shows the files providing input and output to DLAIC's overlays.

In subsections 3.4.2 through 3.4.9 the matrices read from and written onto each file are listed. (See secs. 6.4 through 6.5 of vol. I, *Engineering and Usage*, for detailed descriptions of the format and content of the files for external communication.) Section 3.6.3 of this volume contains the same infomation for L217 (EOM)'s temporary scratch files.

3.4.1 OVERLAY(L217,4,1), DLACDS

Purpose of DLACDS

DLACDS reads card input data directing the processing of Doublet Lattice (L216) AIC matrices. (See card set 3.0 in vol. I of this document, *Engineering and Usage*.) Options, constants, and file names are stored in labelled common blocks for later use. The card data defining the correspondence between Doublet Lattice bodies (thin bodies and slender bodies) and the L215 (INTERP) modal interpolation surfaces are stored in the arrays {IBDTAB} and {ICSTAB} and written onto the temporary storage file S1L217.

The macro flow chart of this overlay is shown in figure 19.

The routines called are displayed in table 14.

I/O Devices of DLACDS

DLACDS reads card set 3 from the input file and prints the card images on the output file with descriptive comments and any necessary diagnostics.

DLACDS writes on the file:

S1L217	The arrays {IBDTAB} and {ICSTAB} (see sec. 3.6.3 for contents)

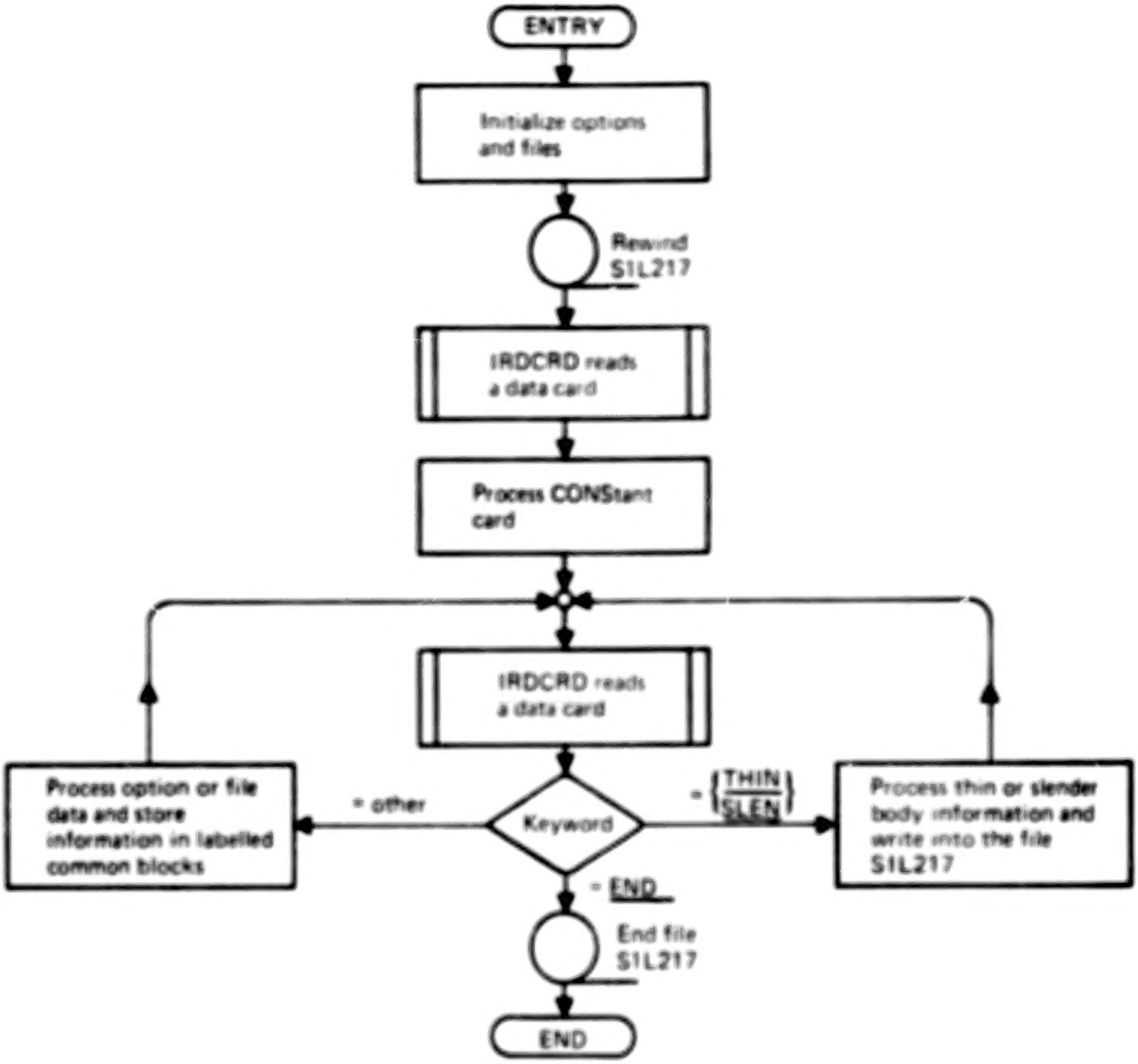

ENTRY
Initialize options and files
Rewind S1L217
IRDCRD reads a data card
Process CONStant card
IRDCRD reads a data card
Keyword
= other
= {THIN / SLEN}
= END
Process option or file data and store information in labelled common blocks
Process thin or slender body information and write into the file S1L217
End file S1L217
END

Figure 19. – Macro Flow Chart of Overlay (L217, 4, 1), DLACDS

Table 14. – Routines Called by DLACDS

```
OVERLAY (L217,4,1)

PROGRAM DLACDS

------------------------------------------------------------


FNDKEY*

IRDCRD*
IFQL*

NAMFIL*

WRTETP*
```

* indicates a routine from the **DYLOFLEX** alternate subroutine library

3.4.2 OVERLAY(L217,4,2), DLAGEO

Purpose of DLAGEO

DLAGEO reads the Doublet Lattice (L216) geometry data from the file NGETP, combines it with the card input data read from S1L217, and prepares geometry arrays governing the calculation of aerodynamic forces. The arrays prepared are written onto the first logical file of S1L217 (see sec. 3.6.3).

Analytical Steps of DLAGEO

DLAGEO performs its tasks in the following steps:

1. Initialize geometry arrays and counters.

2. Call RDLGEO to read the Doublet Lattice (L217) geometry data from the file NGETP.

   Rewind S1L217, then repeat steps 3 through 5 for each body (thin or slender) defined via card input to DLACDS; IBOD = 1, NBOD.

3. Read from S1L217 the array $\{IBDTAB\}_{IBOD}$, the card input data associated with the body. If control surfaces are attached to the body, the array $\{ICSTAB\}$ is read from S1L217 to define the aerodynamic elements on each of the control sufaces.

4. Add to the array $\{ISURF\}$ and build the IBOD portion of the array $\{IPNSRF\}$.

$\{ISURF\}$	A table of modal interpolation surfaces
$\{IPNSRF\}$	A table providing a correspondence between aerodynamic elements and modal interpolation surfaces

5. Build the IBOD portion of the arrays:

$[F\overset{\bullet}{A}C]$	Used to double the force of slender body elements on the plane of symmetry
$[\overset{\bullet}{S}F]$	Used to double the force on elements off the plane of symmetry
$\{IGUSTZ\}$	Indicates the gust zone in which each aerodynamic element falls
$[\overset{\bullet}{R}G]$	The gust rotation matrix

6. Build the array $[SIGMA]$ to define the correspondence between interference body elements and slender body segments. The $[SIGMA]$ is used to add the interference body forces to the slender body segments.

7. Call PRTGFP and PRTGCP to print Doublet Lattice (L216) force point and control point geometry.

8. Transform the reference axis coordinates of all bodies to local structural coordinates using the subroutine GTOLT.

9. Compress the geometry arrays from NTOTF to NAFP elements by eliminating all interference body element entries.

   NTOTF = Total number of force points

   NAFP = Number of aerodynamics force points on all slender and thin bodies

10. Call WRTGEO to write geometry arrays onto the file S1L217 (see sec. 3.6.3).

11. Read the aerodynamic control matrix from NAETP and extract the reduced frequencies.

12. Return to the calling program.

The macro flow chart of this overlay is shown in figure 20.

The routines called are displayed in table 15.

I/O Devices of DLAGEO

DLAGEO reads from the files:

NGETP	Doublet Lattice (L216) geometry arrays (see sec. 6.4.4 of vol. I)
NAETP	Doublet Lattice (L216) aerodynamic control matrix (see sec. 6.4.5 of vol. I)
S1L217	Arrays $\{IBDTAB\}$ and $\{ICSTAB\}$

DLAGEO writes onto the files:

OUTPUT	Geometry tables for force and control points
S1L217	All geometry arrays required by subsequent DLAIC secondary overlays (see sec. 3.6.3)

3.4.3 OVERLAY(L217,4,3), DLAMOD

Purpose of DLAMOD

DLAMOD interpolates over the mode shapes defined in an SA array from L217 (INTERP) to find:

$[\phi_{FP}]$	Modal deflections at force points
$[\phi_{CP}]$	Modal deflections at control points
$[\phi'_{CP}]$	Modal slopes at control points
$[\phi''_{CP}]$	Second derivatives of modes at the control points

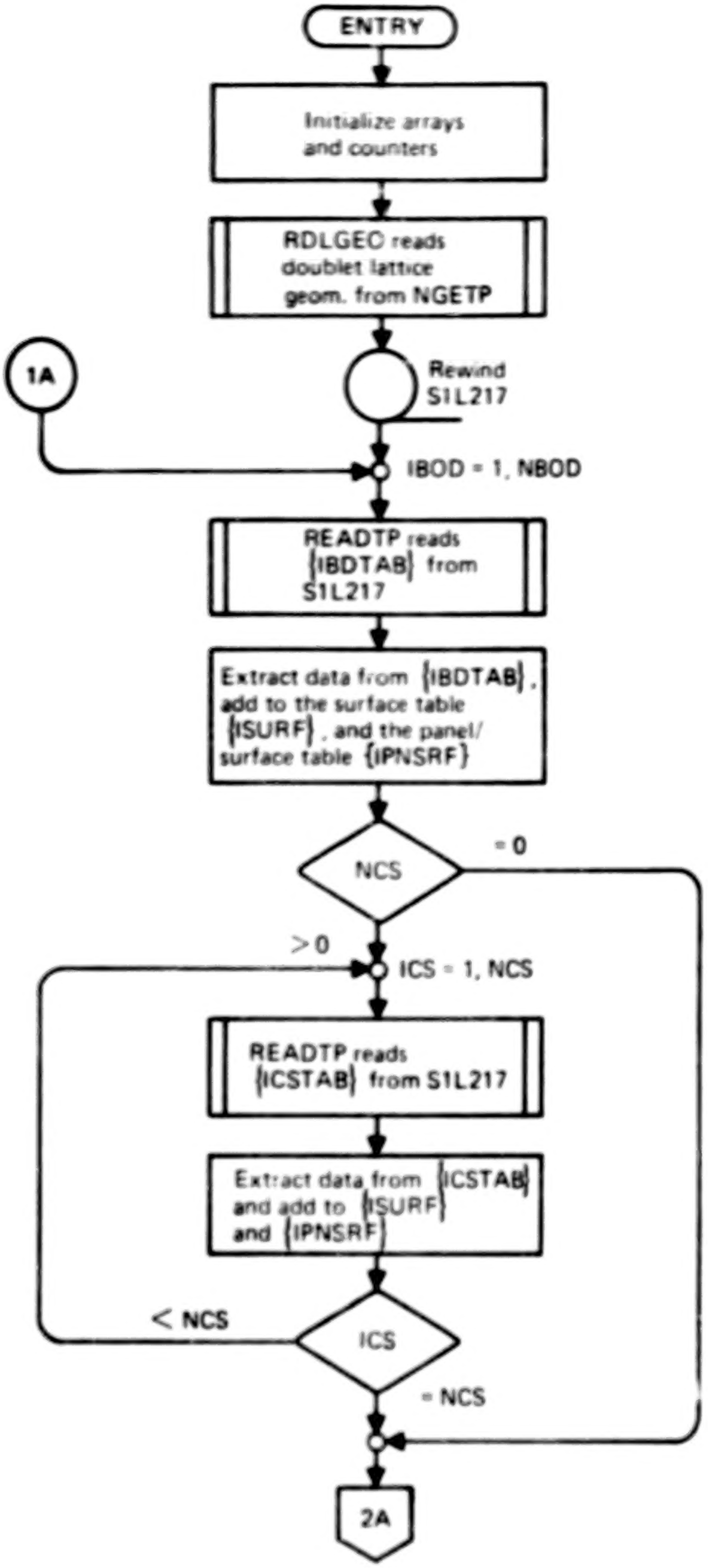

ENTRY
Initialize arrays and counters
RDLGEO reads doublet lattice geom. from NGETP
1A
Rewind S1L217
IBOD = 1, NBOD
READTP reads {IBDTAB} from S1L217
Extract data from {IBDTAB}, add to the surface table {ISURF}, and the panel/surface table {IPNSRF}
NCS
= 0
> 0
ICS = 1, NCS
READTP reads {ICSTAB} from S1L217
Extract data from {ICSTAB} and add to {ISURF} and {IPNSRF}
< NCS
ICS
= NCS
2A

Figure 20. – Macro Flow Chart of Overlay (L217, 4, 2), DLAGEO

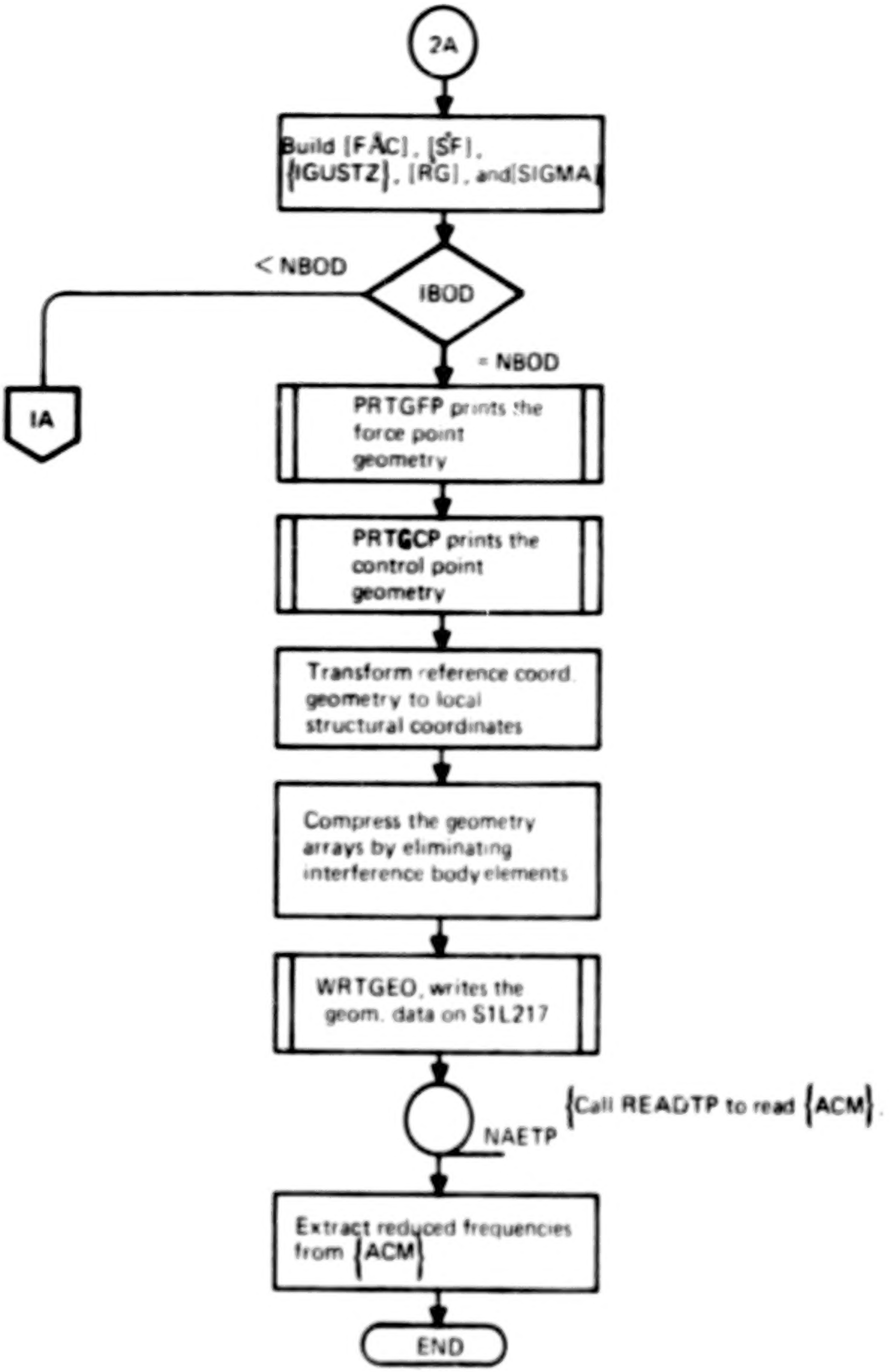

2A
Build [FAC], [SF], {IGUSTZ}, [RG], and [SIGMA]
< NBOD
IBOD
= NBOD
IA
PRTGFP prints the force point geometry
PRTGCP prints the control point geometry
Transform reference coord. geometry to local structural coordinates
Compress the geometry arrays by eliminating interference body elements
WRTGEO, writes the geom. data on S1L217
NAETP
{Call READTP to read {ACM}}.
Extract reduced frequencies from {ACM}
END

Figure 20. – (Concluded)

Table 15. – Routines Called by DLAGEO

```
OVERLAY(L217,4,2)

PROGRAM DLAGEO

-----------------------------------------------


GTOLT*

IRQL*

PRTGCP

PRTGFP

RDLGEO           FETAD*

                 FETDEL*

                 READTP*

WRTGEO           WRTETP*
```

* indicates a routine from the DYLOFLEX alternate subroutine library

Analytical Steps of DLAMOD

DLAMOD calls AINTL, a DYLOFLEX library routine, to perform the interpolation. If more than 20 modes are defined, the arrays are generated and written onto the temporary file S1L217 in partitions with up to 20 modes per partition. See section 3.6.3 for the format of S1L217.

The macro flow chart of this overlay is shown in figure 21.

The routines called are displayed in table 16.

I/O Devices of DLAMOD

DLAMOD reads from the files:

SATAP	{SA} arrays defining modal data
S1L217	Geometry arrays

$$\left.\begin{matrix}\{\text{SURFTB}\}\\ \{\text{IPNSRF}\}\\ \{\text{X}\}\\ \{\text{Y}\}\\ \{\text{IPNSCP}\}\\ \{\text{XCP}\}\\ \{\text{YCP}\}\end{matrix}\right\}\ \text{See section 3.6.3}$$

DLAMOD writes onto the file:

S1L217	Interpolated modal data (see sec. 3.6.3)

3.4.4 OVERLAY(L217,4,4), CPANDW

Purpose of CPANDW

For a particular frequency CPANDW forms the arrays:

$$[CP_{SB}] = -2\pi\left[[\dot{R}'] + \frac{i\omega}{2v}[\dot{R}]\right]\left[[\phi'_{CP}]_{SB} + \frac{i\omega}{v}[\phi_{CP}]_{SB}\right] - \pi[\dot{R}]\left[[\phi''_{CP}]_{SB} + \frac{i\omega}{v}[\phi'_{CP}]_{SB}\right]$$

For a quasi-steady solution, the factors multiplying the imaginary parts change to 0.0, 1/v, and 1/v, respectively.

$$[CPG_{SB}] = -\frac{2\pi}{v}[\dot{R}]\ [\mathring{R}G]_{SB}[G\dot{C}]_{SB}$$

$$[W_{TB}] = -\left[[\phi'_{CP}]_{TB} + \frac{i\omega}{v}[\phi_{CP}]_{TB}\right]$$

$$[WG_{TB}] = \frac{1}{v}[\dot{R}G]_{TB}[G\dot{C}]_{TB}$$

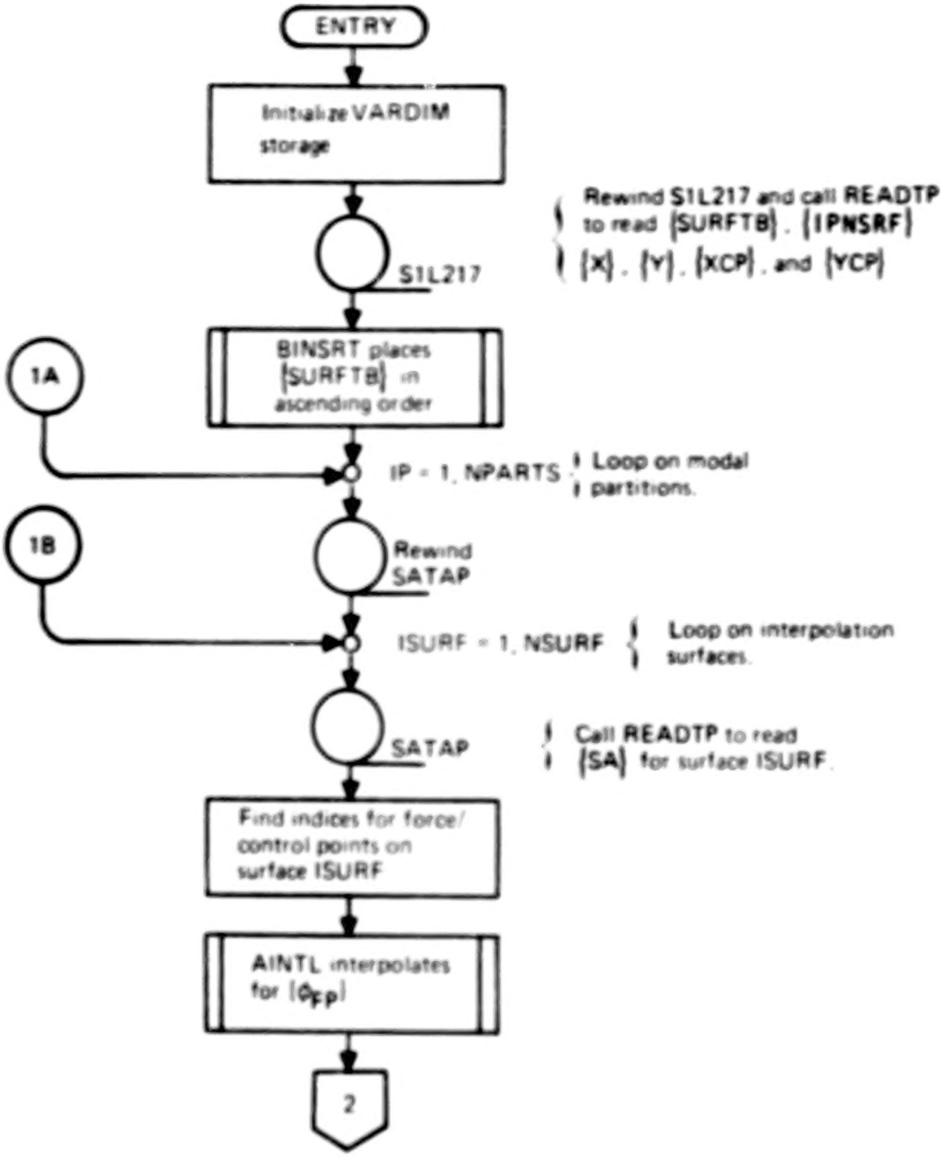

ENTRY
Initialize VARDIM storage
Rewind S1L217 and call READTP to read {SURFTB}, {IPNSRF} {X}, {Y}, {XCP}, and {YCP}
S1L217
1A
BINSRT places {SURFTB} in ascending order
IP = 1, NPARTS
Loop on modal partitions.
1B
Rewind SATAP
ISURF = 1, NSURF
Loop on interpolation surfaces.
SATAP
Call READTP to read {SA} for surface ISURF.
Find indices for force/control points on surface ISURF
AINTL interpolates for [ϕ_{FP}]
2

Figure 21. – Macro Flow Chart of Overlay (L217, 4, 3), DLAMOD

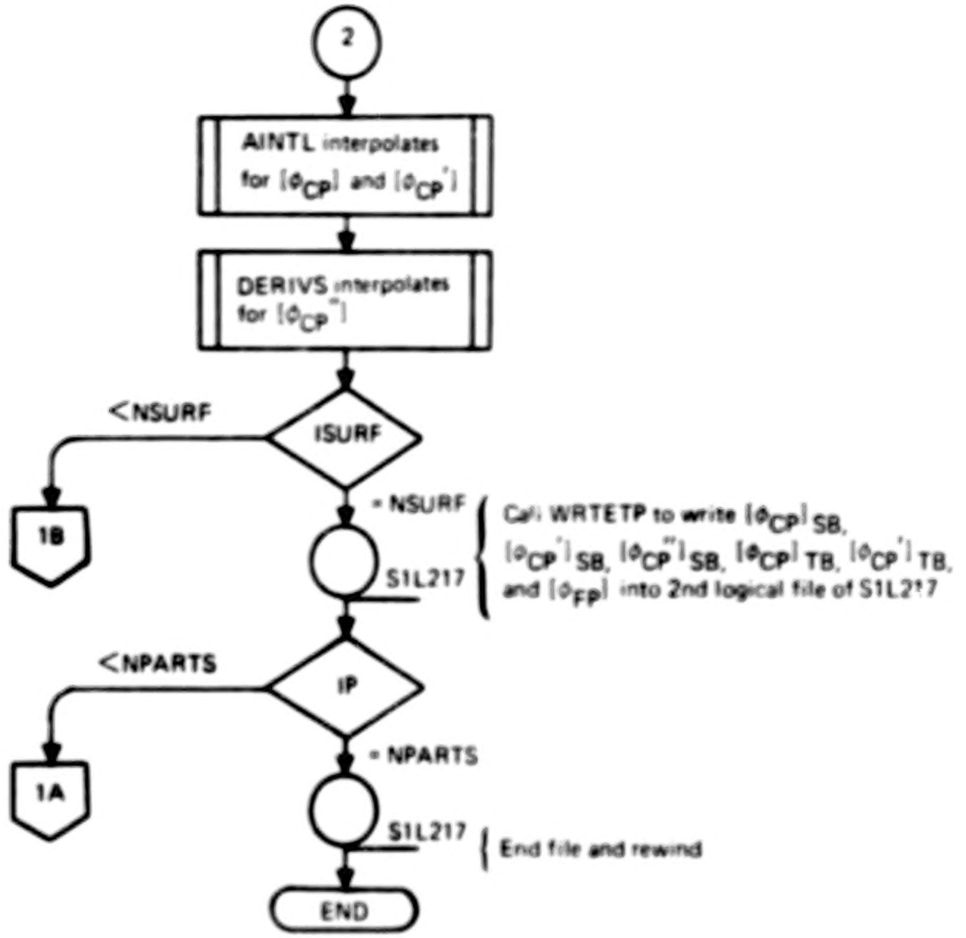

2
AINTL interpolates for [φCP] and [φCP']
DERIVS interpolates for [φCP'']
<NSURF
ISURF
1B
= NSURF
S1L217
Call WRTETP to write [φCP] SB, [φCP'] SB, [φCP''] SB, [φCP] TB, [φCP'] TB, and [φFP] into 2nd logical file of S1L217
<NPARTS
IP
1A
= NPARTS
S1L217
End file and rewind
END

Figure 21. – (Concluded)

Table 16. – Routines Called by DLAMOD

```
OVERLAY(L217,4,3)

PROGRAM DLAMOD

------------------------------------------


AINTL*

BINSRT

DERIVS

FETAC*

FETDEL*

INITIR*

PRINTM*

READTP*

SETMFL

STARTR*

WRTETP*
```

```
* indicates a routine from the DYLOFLEX
  alternate subroutine library
```

The macro flow chart of this overlay is shown in figure 22.

The routines called are displayed in table 17.

I/O Devices of CPANDW

CPANDW reads from the file:

S1L217 Geometry arrays

$$\left.\begin{array}{l}[GC]\\ [\mathring{R}G]\\ [\mathring{R}]\\ [\mathring{R}']\end{array}\right\}\text{ See section 3.6.3}$$

and the modal data arrays

$$\left.\begin{array}{l}[\phi_{CP}]_{SB},\ [\phi'_{CP}]_{SB},\ [\phi''_{CP}]_{SB},\\ [\phi_{CP}]_{TB},\ \text{and}\ [\phi'_{CP}]_{TB}\end{array}\right\}\text{ See section 3.6.3}$$

CPANDW writes onto the file:

S1L217 The arrays

$$\left.\begin{array}{l}[CP_{SB}]\\ [CPG_{SB}]\\ [W_{TB}]\\ [WG_{TB}]\end{array}\right\}\text{ See section 3.6.3}$$

3.4.5 OVERLAY(L217,4,5), FORMWS

Purpose for FORMWS

FORMWS forms the matrices:

$$[W] = \begin{array}{c}[W_{TB}]\\ \hline [\ 0\ ]\end{array} + [F][CP_{SB}]$$

$$[WG] = \begin{array}{c}[WG_{TB}]\\ \hline [\ 0\ ]\end{array} + [F][CPG_{SB}]$$

and writes them onto the file NTP4 to be used as the right hand sides of the ΔCp solution in SOLVDW.

The macro flow chart of this overlay is shown in figure 23.

The routines called are displayed in table 18.

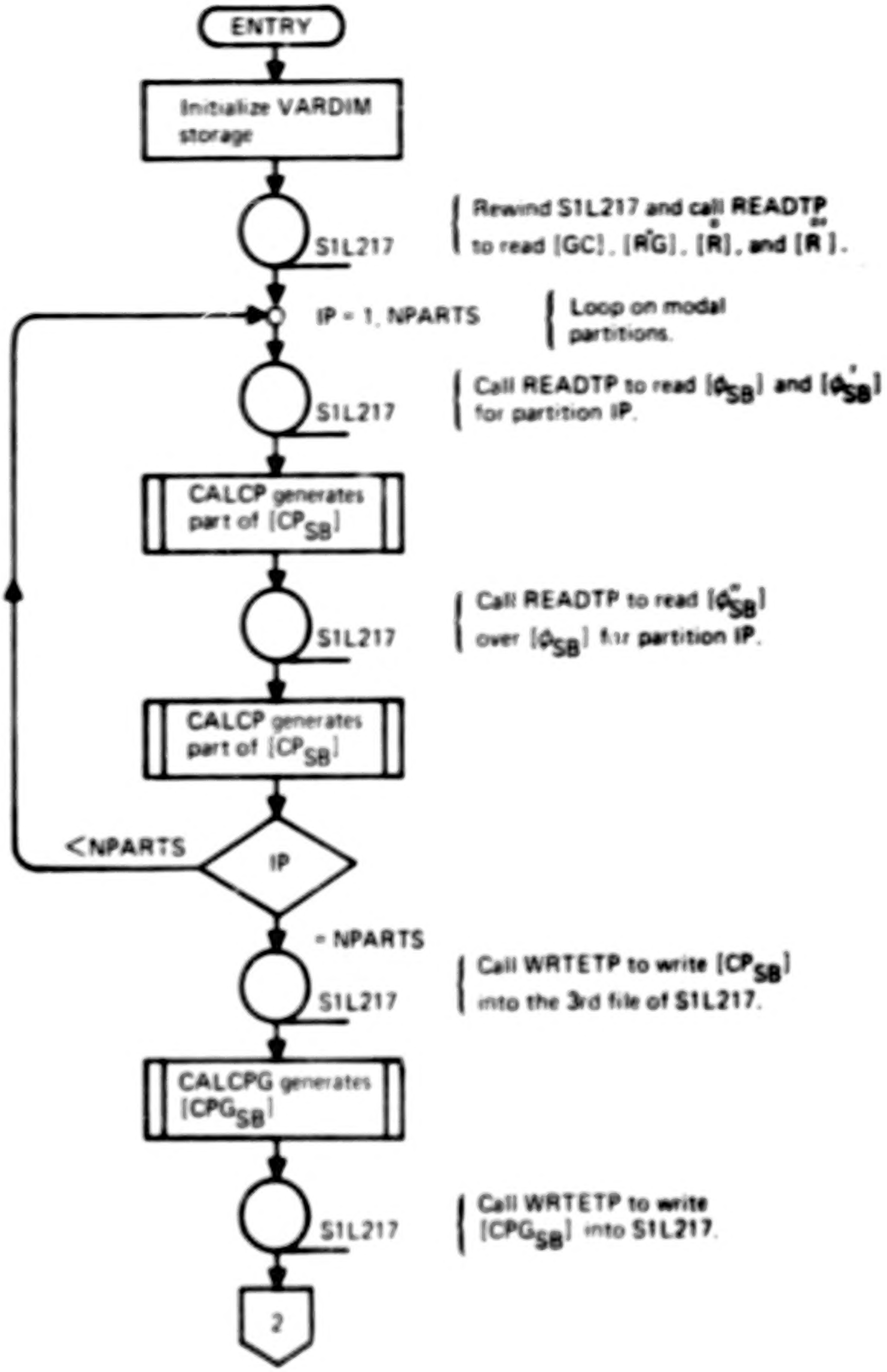

ENTRY
Initialize VARDIM storage
S1L217
Rewind S1L217 and call READTP to read [GC], [$\dot{R}$G], [$\dot{R}$], and [$\ddot{R}$].
IP = 1, NPARTS
Loop on modal partitions.
S1L217
Call READTP to read [ϕ_{SB}] and [ϕ'_{SB}] for partition IP.
CALCP generates part of [CP_{SB}]
S1L217
Call READTP to read [ϕ''_{SB}] over [ϕ_{SB}] for partition IP.
CALCP generates part of [CP_{SB}]
<NPARTS
IP
= NPARTS
S1L217
Call WRTETP to write [CP_{SB}] into the 3rd file of S1L217.
CALCPG generates [CPG_{SB}]
S1L217
Call WRTETP to write [CPG_{SB}] into S1L217.
2

Figure 22. – Macro Flow Chart of Overlay (L217, 4, 4), CPANDW

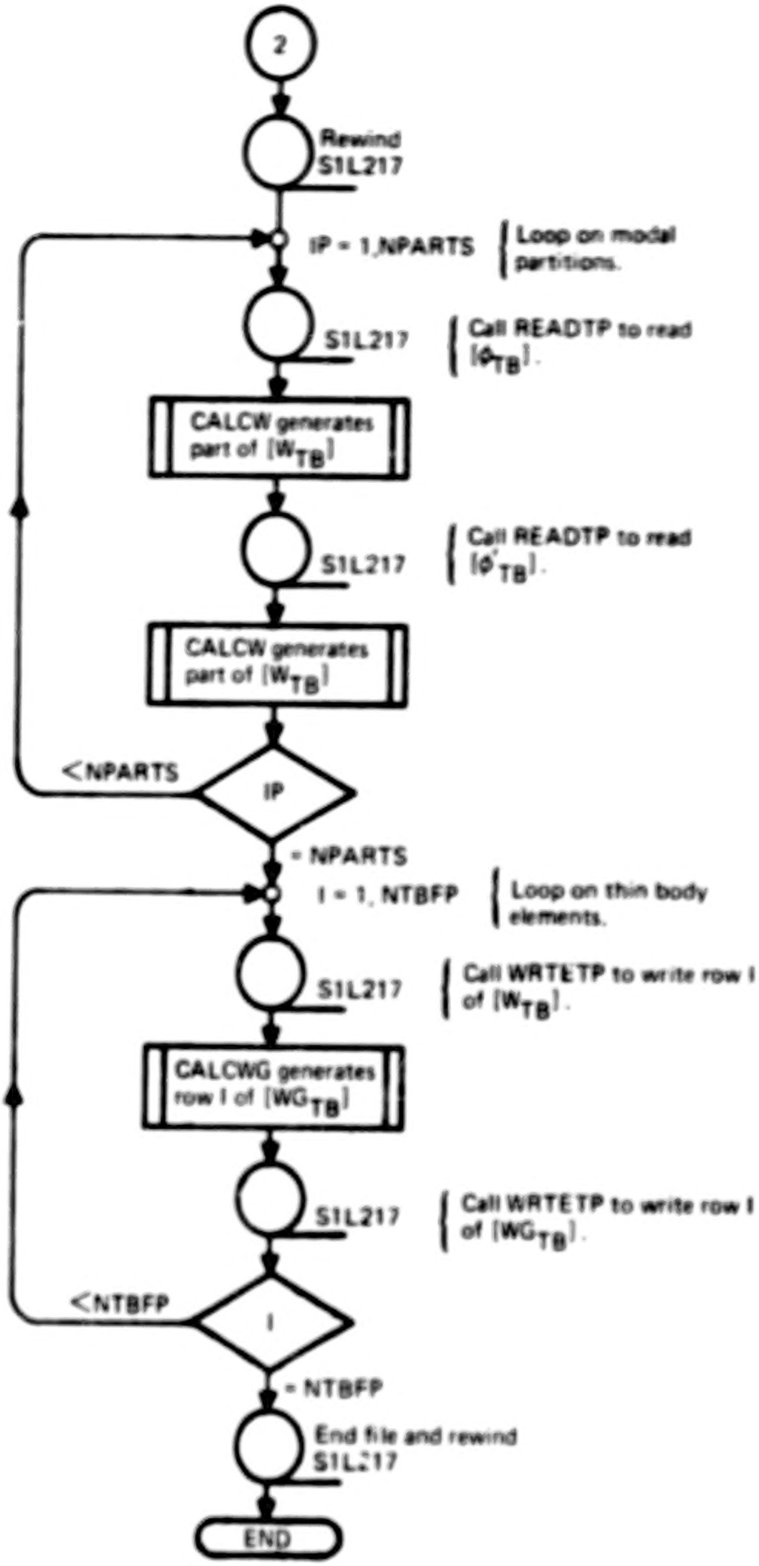

2
Rewind S1L217
IP = 1,NPARTS
Loop on modal partitions.
S1L217
Call READTP to read [ϕ_{TB}].
CALCW generates part of [W_{TB}]
S1L217
Call READTP to read [ϕ'_{TB}].
CALCW generates part of [W_{TB}]
<NPARTS
IP
= NPARTS
I = 1, NTBFP
Loop on thin body elements.
S1L217
Call WRTETP to write row I of [W_{TB}].
CALCWG generates row I of [WG_{TB}]
S1L217
Call WRTETP to write row I of [WG_{TB}].
<NTBFP
I
= NTBFP
End file and rewind S1L217
END

Figure 22. — (Concluded)

Table 17. – Routines Called by CPANDW

```
OVERLAY(L217,4,4)

PROGRAM CPANDW

-----------------------------------------------


CALCP

CALCPG

CALCW

CALCWG

DELETR*

INITIR*

PRINTM*

PRNTCM*

READTP*

SETMFL

STARTR*

WRTETP*
```

* indicates a routine from the DYLOFLEX
alternate subroutine library

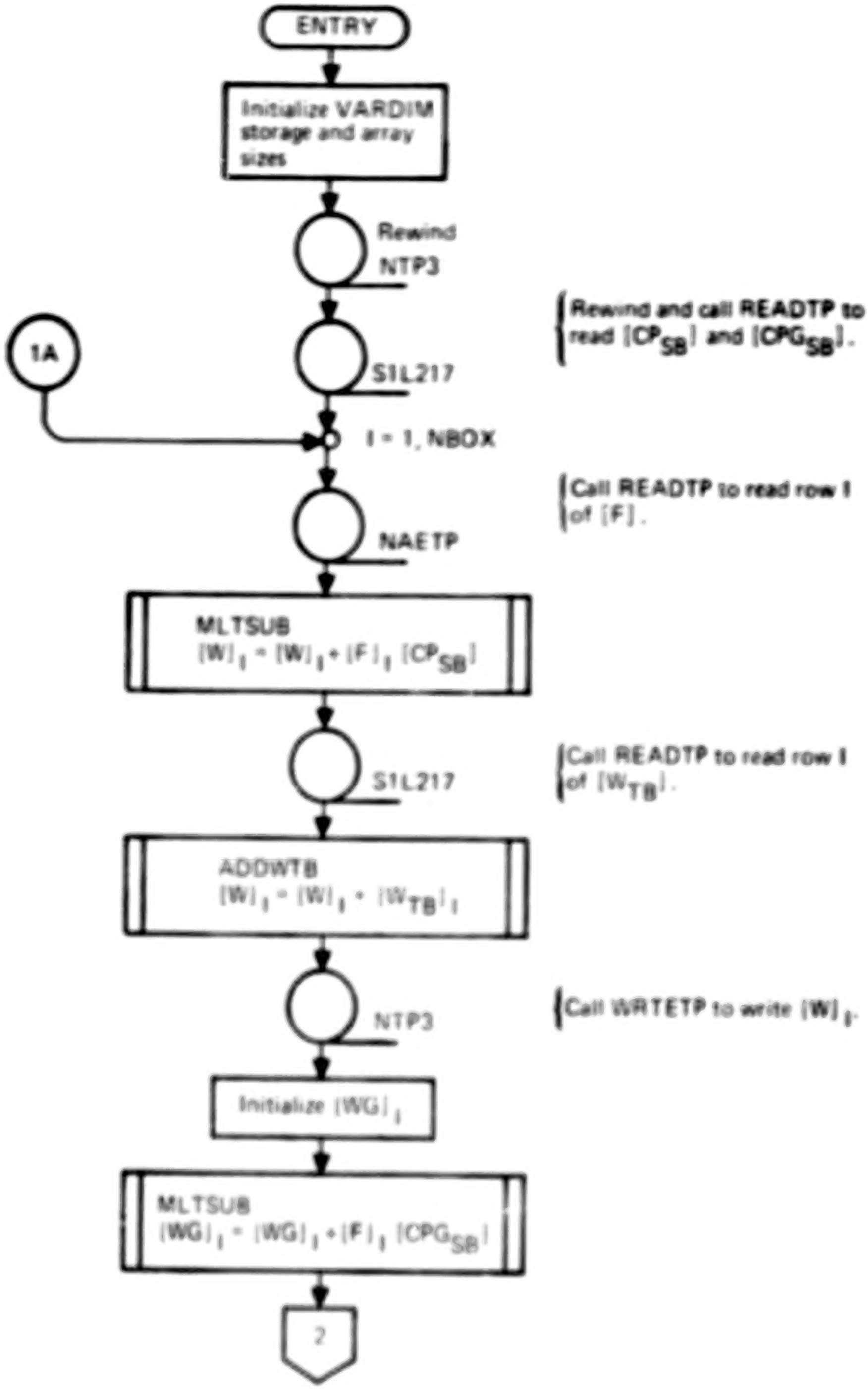

ENTRY
Initialize VARDIM storage and array sizes
Rewind NTP3
Rewind and call READTP to read [CP_{SB}] and [CPG_{SB}].
S1L217
1A
I = 1, NBOX
Call READTP to read row I of [F].
NAETP
MLTSUB
$\{W\}_I = \{W\}_I + \{F\}_I [CP_{SB}]$
Call READTP to read row I of [W_{TB}].
S1L217
ADDWTB
$\{W\}_I = \{W\}_I + \{W_{TB}\}_I$
Call WRTETP to write $\{W\}_I$.
NTP3
Initialize $\{WG\}_I$
MLTSUB
$\{WG\}_I = \{WG\}_I + \{F\}_I [CPG_{SB}]$
2

Figure 23. – Macro Flow Chart of Overlay (L217, 4, 5), FORMWS

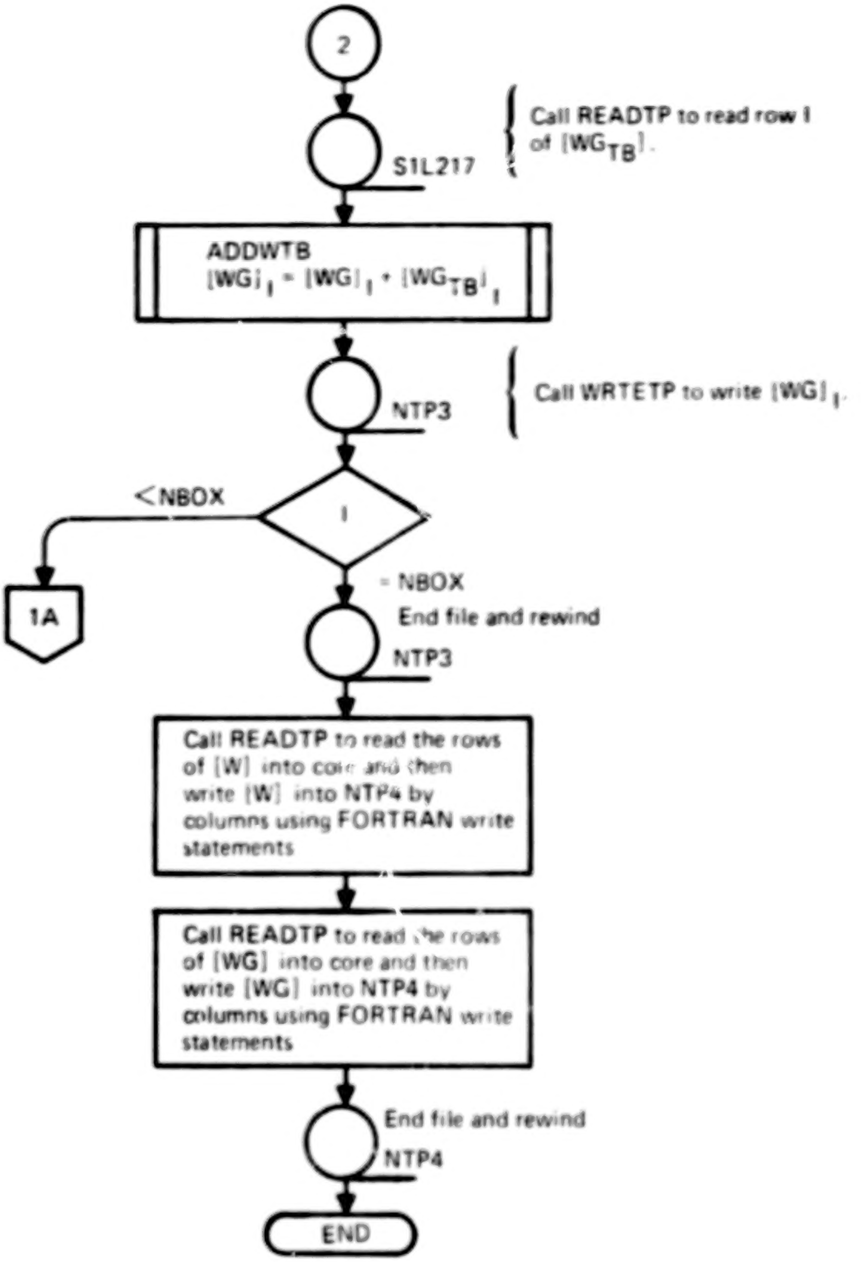

2
S1L217
Call READTP to read row I of [WG$_{TB}$].
ADDWTB
[WG]$_I$ = [WG]$_I$ + [WG$_{TB}$]$_I$
NTP3
Call WRTETP to write [WG]$_I$.
I
<NBOX
1A
= NBOX
End file and rewind
NTP3
Call READTP to read the rows of [W] into core and then write [W] into NTP4 by columns using FORTRAN write statements
Call READTP to read the rows of [WG] into core and then write [WG] into NTP4 by columns using FORTRAN write statements
End file and rewind
NTP4
END

Figure 23. – (Concluded)

Table 18. – Routines Called by FORMWS

```
OVERLAY(L217,4,5)

PROGRAM FORMWS

----------------------------------------


ADDWTB

DELETR*

FETAD*

FETDEL*

INITIR*

MLTSUB

PRNTCM*

READTP*

RETURNF*

SETMFL

STARTR*

WRTETP*
```

```
* indicates a routine from the DYLOFLEX
  alternate subroutine library
```

I/O Devices of FORMWS

FORMWS reads from the files:

NAETP	Matrix $[F]$ by rows
S1L217	Matrices $[CP_{SB}]$ and $[CPG_{SB}]$
NTP3	Matrices $[W]$ and $[WG]$ after having written by rows

FORMWS writes onto the files:

NTP3	Matrices $[W]$ and $[WG]$ by rows
NTP4	Matrices $[W]$ and $[WG]$ by columns

3.4.6 OVERLAY(L217,4,6), SOLVDW

Purpose of SOLVDW

SOLVDW solves the following equation for $[\Delta Cp]$:

$$[D]\ [\Delta Cp] = [W/WG]$$

Analytical Steps of SOLVDW

SOLVDW performs its task in the following steps:

1. Determine available length of blank common.
2. Initialize the files NTP3, NTP4, and NTP5.
3. Call COPYDQ to copy the quasi-inverse of $[D]$ from NAETP to NTP5.
4. Call FUTSOL to solve the equation.
5. Close scratch files and return to the calling program.

The macro flow chart of this overlay is shown in figure 24.

The routines called are displayed in table 19.

I/O of SOLVDW

SOLVDW reads from the files:

NAETP	Quasi-inverse of $[D]$
NTP4	Right-hand-side matrices $[W]$ and $[WG]$ by columns

SOLVDW writes onto the file:

NTP3	Solution columns

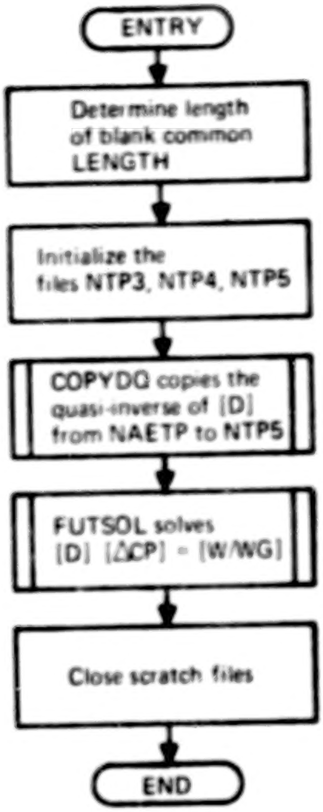

ENTRY
Determine length of blank common LENGTH
Initialize the files NTP3, NTP4, NTP5
COPYDQ copies the quasi-inverse of [D] from NAETP to NTP5
FUTSOL solves [D] [ΔCP] = [W/WG]
Close scratch files
END

Figure 24. – Macro Flow Chart of Overlay (L217, 4, 6), SOLVDW

Table 19. – Routines Called by SOLVDW

```
OVERLAY(L217,4,6)

PROGRAM SOLVDW

---------------------------------------------


COPYDQ

FETAD+

FETDEL+

FUTSOL         { FETAD+
               {
               { FETDEL+
               {
               { RETURNF+

REQFL+

RETURNF+
```

+ indicates a routine from the **DYLOFLEX** alternate subroutine library

SOLVDW also writes/reads data on/from the files MT, NIN, NOUT, and NATAPE during the solution inside the subroutine FUTSOL.

MT = 4LFUT1

NIN = 4LFUT2

NOUT = 4LFUT3

NATAPE = 4LFUT4

3.4.7 OVERLAY(L217,4,7), DLAFRC

Purpose of DLAFRC

DLAFRC generates aerodynamic forces based upon Doublet Lattice (L216) AIC matrices:

$$[FR] = [F\mathring{A}C] \left[\begin{array}{c} [\,0\,] \\ \hline q[\mathring{A}_{SB}]\,[CP_{SB}] \end{array} + q[\dot{\Sigma}]\,[\mathring{A}_{TB/IB}]\,[\Delta CP] \right]$$

$$[FG] = [F\mathring{A}C] \left[\begin{array}{c} [\,0\,] \\ \hline q[\mathring{A}_{SB}]\,[CPG_{SB}] \end{array} + q[\dot{\Sigma}]\,[\mathring{A}_{TB/IB}]\,[\Delta CP_G] \right]$$

Analytical Steps of DLAFRC

DLAFRC performs its task in the following steps:

1. **Initialize VARDIM storage and read $\{A\}$, $[\Sigma]$, $[F\mathring{A}C]$, and $[CP_{SB}]$ into core.**

   Repeat step 2 for each mode.

2. **Read a column of $[\Delta Cp]$ from NTP3, call CALCFS to form a column of $[FR]$, and write partitions of $[FR]$ (with IPSIZE columns) onto S3L217.**

3. **Initialize $\{FG\}_{IG}$ and read $[CPG_{SB}]$ from S1L217.**

   Repeat step 4 for each gust zone.

4. **Read a column of $[\Delta Cp_G]$ from NTP3, call CALCFS to form a column of $[FG]$, and write $\{FG\}_{Zone}$ onto S3L217.**

5. **Return to the calling program.**

The macro flow chart of this overlay is shown in figure 25.

The routines called are displayed in table 20.

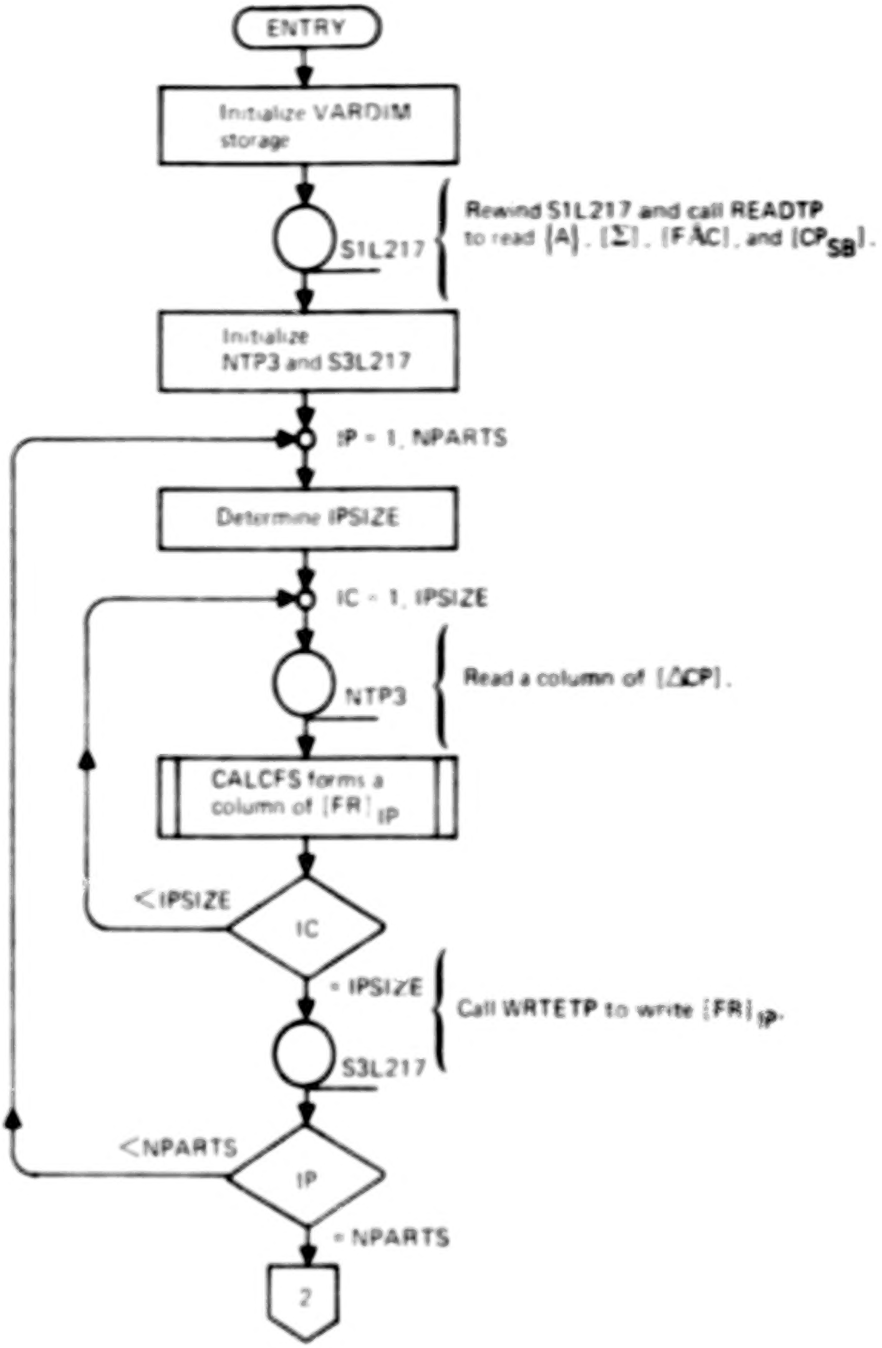
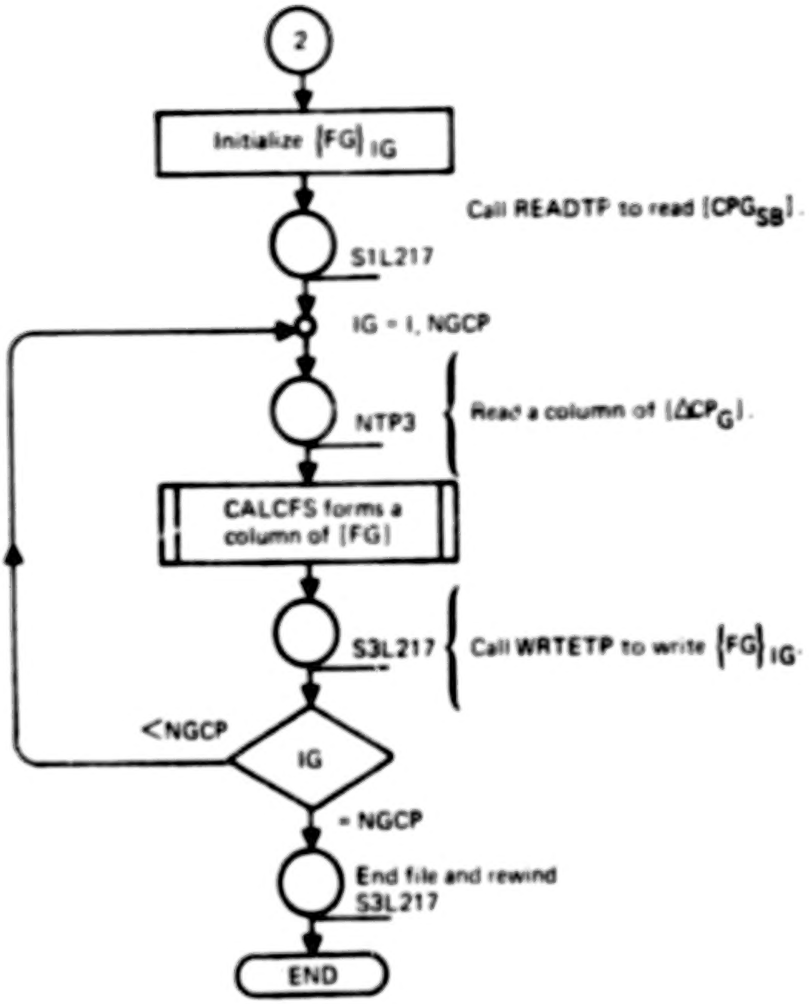

ENTRY
Initialize VARDIM storage
S1L217
Rewind S1L217 and call READTP to read [A], [Σ], [FÃC], and [CP_SB].
Initialize NTP3 and S3L217
IP = 1, NPARTS
Determine IPSIZE
IC = 1, IPSIZE
NTP3
Read a column of [ΔCP].
CALCFS forms a column of [FR]_IP
<IPSIZE
IC
= IPSIZE
Call WRTETP to write [FR]_IP.
S3L217
<NPARTS
IP
= NPARTS
2

Figure 25. – Macro Flow Chart of Overlay (L217, 4, 7), DLAFRC



2
Initialize {FG}IG
Call READTP to read {CPGSB}.
S1L217
IG = 1, NGCP
NTP3
Read a column of {ΔCPG}.
CALCFS forms a column of {FG}
S3L217
Call WRTETP to write {FG}IG.
<NGCP
IG
= NGCP
End file and rewind S3L217
END

Figure 25. – (Concluded)

Table 20. – Routines Called by DLAFRC

```
OVERLAY(L217,4,7)

PROGRAM DLAFRC

--------------------------------------------


CALCFS

DELETR*

FETAD*

FETDEL*

PRNTCM*

INITIR*

READTP*

RETURNF*

SETMFL

STARTR*

WRTETP*
```

```
* indicates a routine from the DYLOFLEX
  alternate subroutine library
```

I/O Devices of DLAFRC

DLAFRC reads from the files:

S1L217 Matrices $\{A\}$, $[\Sigma]$, $[F\dot{A}C]$, $[CP_{SB}]$, and $[CPG_{SB}]$

NTP3 Solution columns, $[\Delta Cp]$ and $[\Delta C_{PG}]$

DLAFRC writes onto the file:

S3L217 Matrices

$[FR]$ in partitions of IPSIZE columns

$[FG]$ as NGCP column matrices

3.4.8 OVERLAY(L217,4,10), DLAODR

Purpose of DLAODR

DLAODR sorts the aerodynamic force matrices according to the interpolation surface numbers specified for each element via card input data. The resulting surface force matrices are written onto EOMLOD.

The macro flow chart of this overlay is shown in figure 26.

The routines called are displayed in table 21.

I/O Devices of DLAODR

DLAODR reads from the files:

S1L217 Matrices

$$\left.\begin{array}{l}\{SURFTB\}\\ \{IPNSRF\}\\ \{X\}\\ \{Y\}\\ \{A\}\end{array}\right\}\text{ See section 3.6.3}$$

S3L217 Matrices $[FR]$ and $[FG]$ (see sec. 3.6.3)

DLAODR writes on the file:

EOMLOD For each surface the matrices

$$\left.\begin{array}{l}[X,Y]_{IS}\\ \{A\}_{IS}\\ [F_1]\\ [F_2]\\ [FG]\end{array}\right\}\text{ See section 6.5.2 of volume I}$$

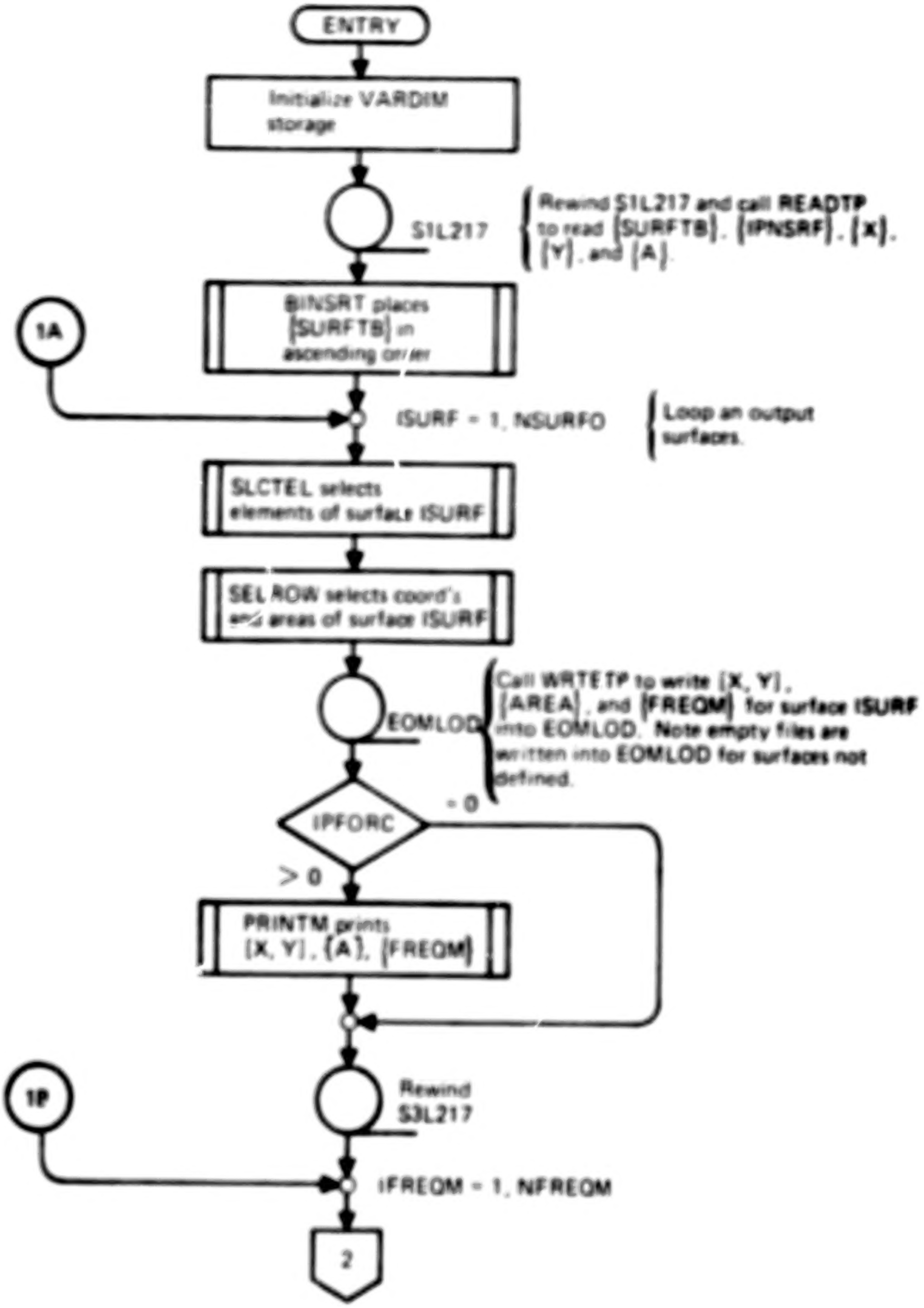

ENTRY
Initialize VARDIM storage
S1L217
Rewind S1L217 and call READTP to read [SURFTB], [IPNSRF], {X}, {Y}, and {A}.
BINSRT places [SURFTB] in ascending order
1A
ISURF = 1, NSURFO
Loop on output surfaces.
SLCTEL selects elements of surface ISURF
SELROW selects coord's and areas of surface ISURF
EOMLOD
Call WRTETP to write {X, Y}, {AREA}, and [FREQM] for surface ISURF into EOMLOD. Note empty files are written into EOMLOD for surfaces not defined.
IPFORC
= 0
> 0
PRINTM prints {X, Y}, {A}, [FREQM]
1P
Rewind S3L217
IFREQM = 1, NFREQM
2

Figure 26. – Macro Flow Chart of Overlay (L217, 4, 10), DLAODR

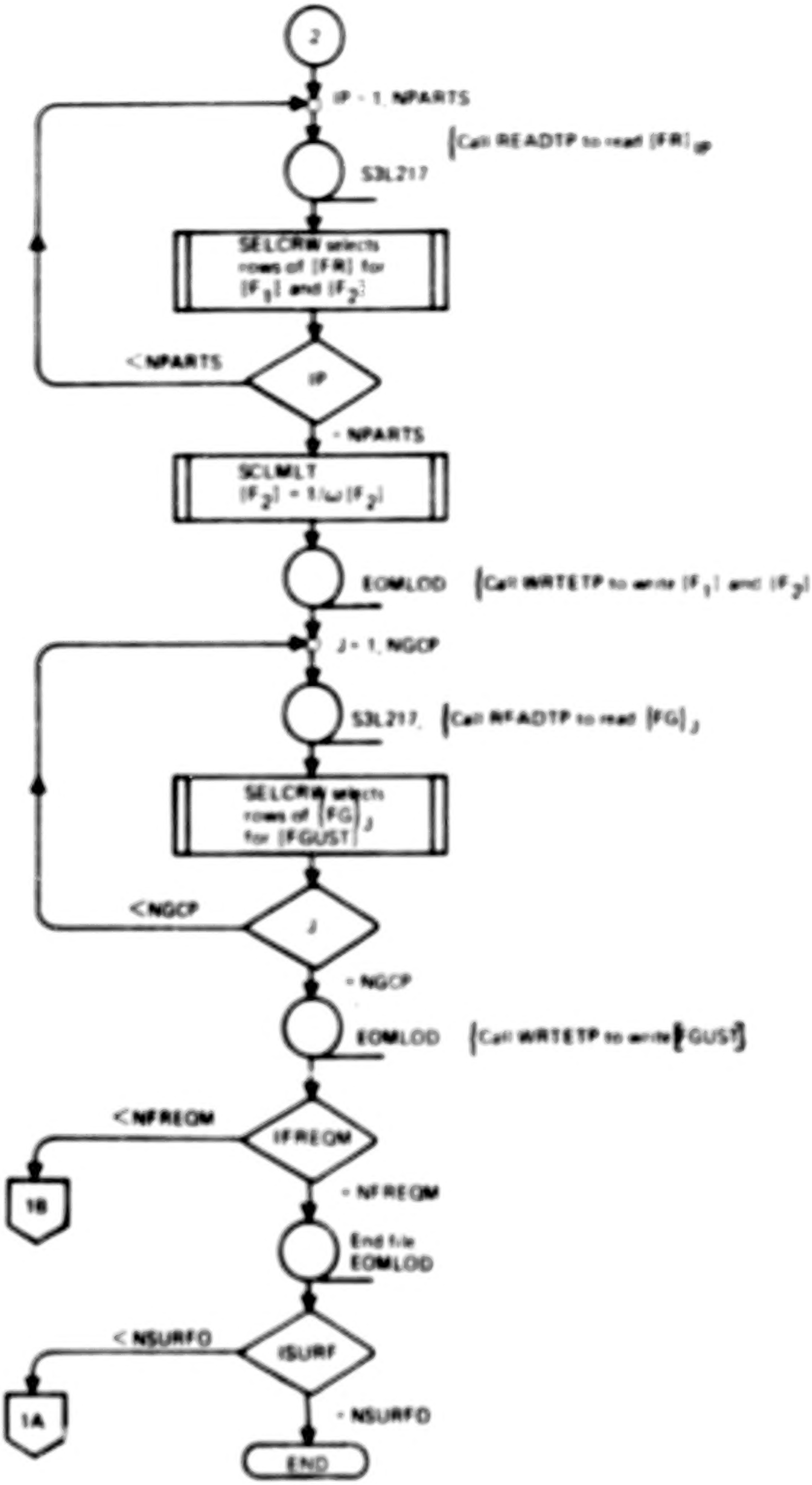

2
IP = 1, NPARTS
S3L217
Call READTP to read [FR]IP
SELCRW selects rows of [FR] for [F1] and [F2]
IP
<NPARTS
= NPARTS
SCLMLT [F2] = 1/ω [F2]
EOMLOD
Call WRTETP to write [F1] and [F2]
J = 1, NGCP
S3L217
Call READTP to read [FG]J
SELCRW selects rows of [FG]J for [FGUST]
J
<NGCP
= NGCP
EOMLOD
Call WRTETP to write [FGUST]
IFREQM
<NFREQM
1B
= NFREQM
End file EOMLOD
ISURF
<NSURFO
1A
= NSURFO
END

Figure 26 — (Concluded)

Table 21. – Routines Called by DLAODR

```
OVERLAY(L217,4,10)

PROGRAM DLAODR

---------------------------------------------


BINSRT

DELETR•

FETAD•

FETDEL•

INITIR•

PRINTM•

PRNTCM•

READTP•

SCLMLT

SELCRW

SELROW

SETMPL

SLCTEL

STARTR•

WRTETP•




• indicates a routine from the DYLOFLEX

  alternate subroutine library
```

3.4.9 OVERLAY(L217,4,11), DLAEOM

Purpose of DLAEOM

DLAEOM generates the aerodynamic equations of motion matrices ($[M_4]$, $[M_5]$, and $[\tilde{\phi}]$) and writes the file EOMTAP. The matrix equations are:

$$[M_4] = -[\phi_{FP}]^T [\overset{\circ}{SF}][FR]_{Real}$$

$$[M_5] = -[\phi_{FP}]^T [\overset{\circ}{SF}][FR]_{Imaginary}$$

$$[\tilde{\phi}] = [\phi_{FP}]^T [\overset{\circ}{SF}][FG]$$

The macro flow chart of this overlay is shown in figure 27.

The routines called are displayed in table 22.

I/O Devices of DLAEOM

DLAEOM reads from the files:

S1L217 Matrices $[\overset{\circ}{SF}]$ (from the first logical file) and $[\phi_{FP}]$ (from the second logical file)

S3L217 Matrices $[FR]$ (by partition) and $[FG]$ (by columns)

DLAEOM writes onto the file EOMTAP the matrices:

$\{HEADER\}$
$[M_1]$
$[M_2]$ (only if damping requested)
$[M_3]$
$\{FREQM\}$

Repeat per frequency
$$\left\{\begin{array}{ll} [M_4] & \\ [M_5] & \\ \{f_1\} & \text{(only for first frequency)} \\ [\tilde{\phi}] & \end{array}\right.$$

3.5 OVERLAY(L217,5,0), DLPRES

Purpose of DLPRES

DLPRES prepares the equations of motion file, EOMTAP, and the aerodynamic force file, EOMLOD (sec. 3.6.2). It uses aerodynamic information from Doublet Lattice (L216) (ref. 4) the generalized forces and the unsteady aerodynamic pressure.

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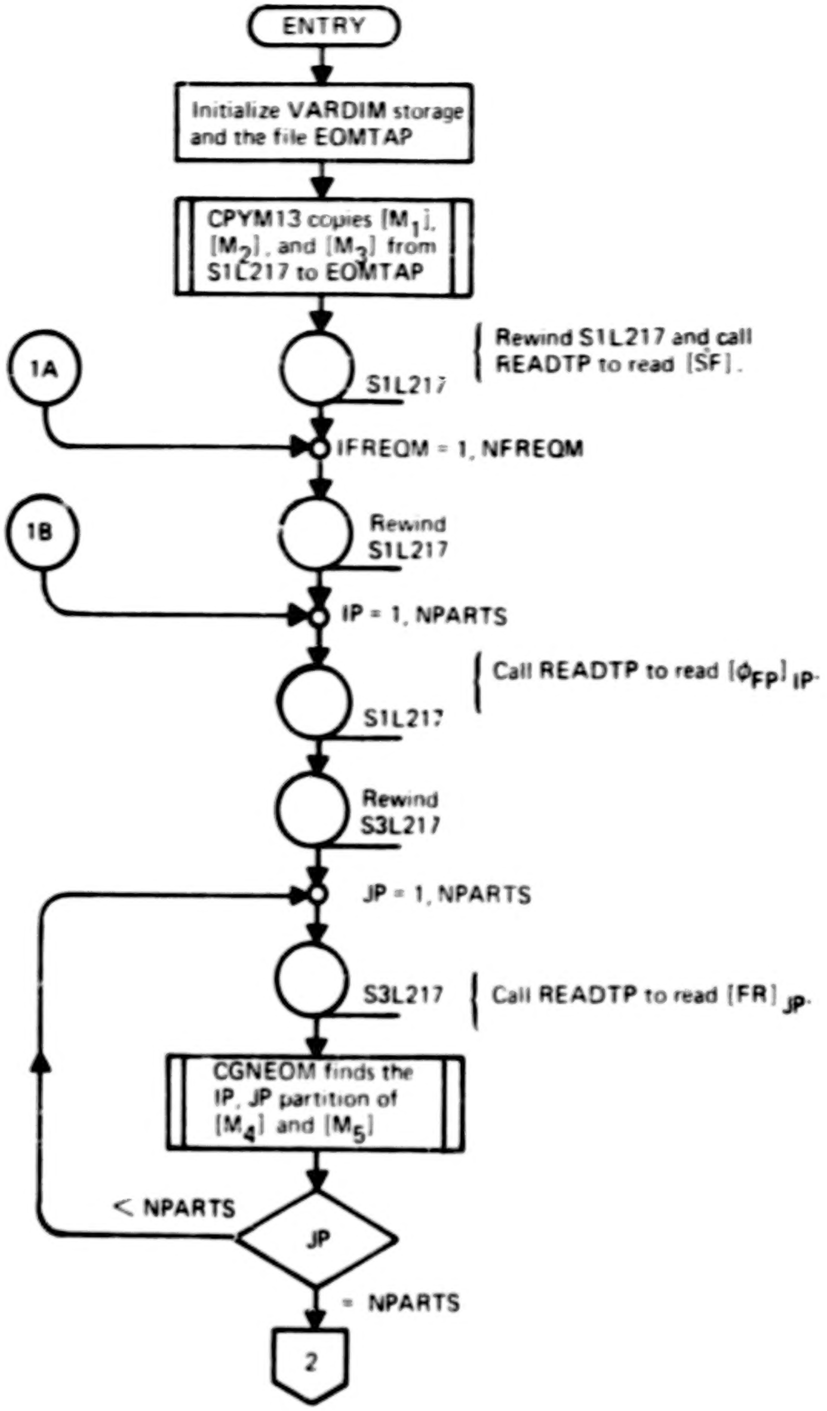

ENTRY
Initialize VARDIM storage and the file EOMTAP
CPYM13 copies [M1], [M2], and [M3] from S1L217 to EOMTAP
S1L217
Rewind S1L217 and call READTP to read [SF].
1A
IFREQM = 1, NFREQM
1B
Rewind S1L217
IP = 1, NPARTS
S1L217
Call READTP to read [φFP] IP.
Rewind S3L217
JP = 1, NPARTS
S3L217
Call READTP to read [FR] JP.
CGNEOM finds the IP, JP partition of [M4] and [M5]
< NPARTS
JP
= NPARTS
2

Figure 27. – Macro Flow Chart of Overlay (L217, 4, 11), DLAEOM

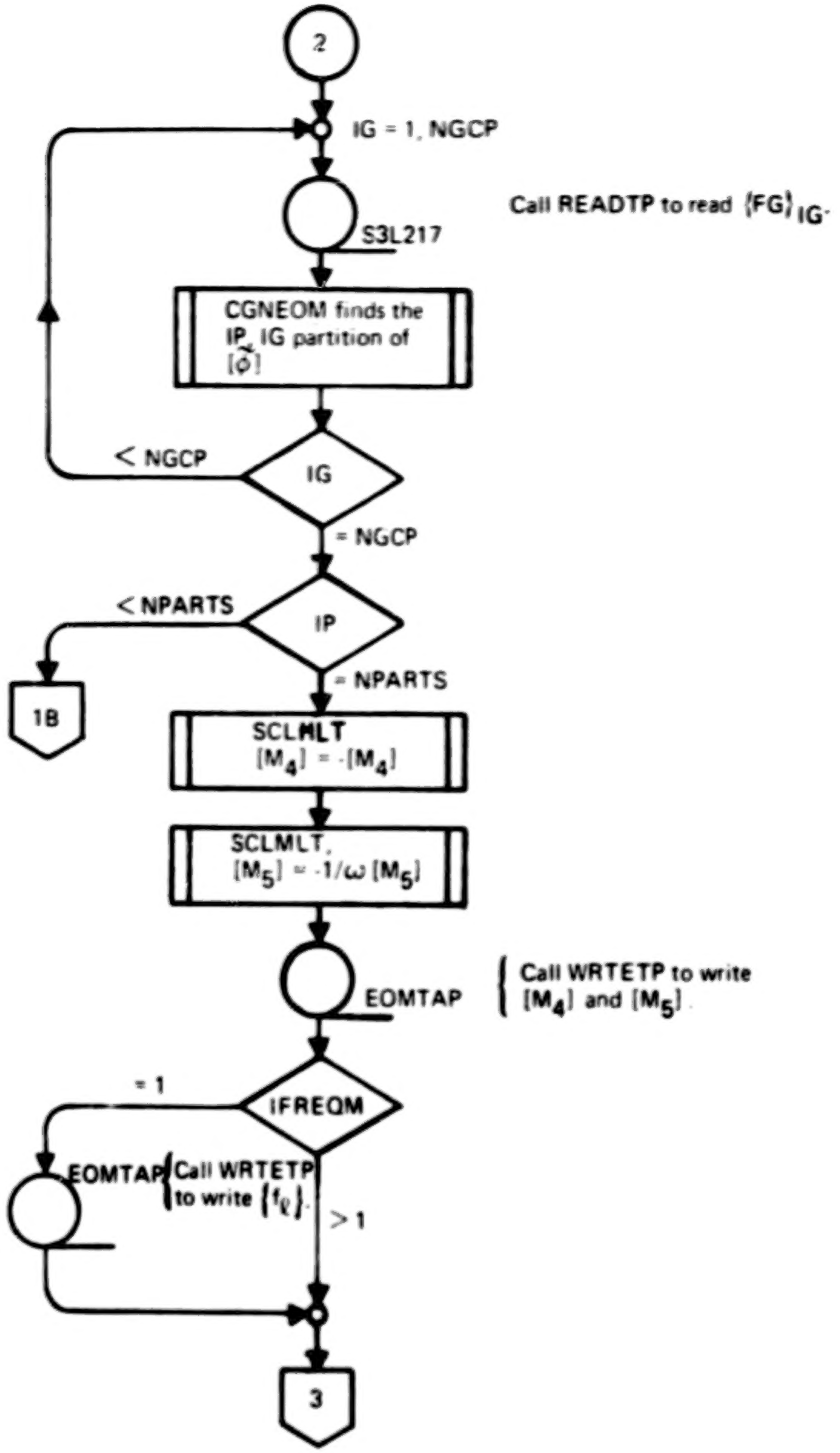

2
IG = 1, NGCP
S3L217
Call READTP to read {FG}_IG.
CGNEOM finds the IP, IG partition of [φ̃]
< NGCP
IG
= NGCP
< NPARTS
IP
= NPARTS
1B
SCLMLT [M_4] = -[M_4]
SCLMLT, [M_5] = -1/ω [M_5]
EOMTAP
Call WRTETP to write [M_4] and [M_5].
= 1
IFREQM
EOMTAP
Call WRTETP to write {f_ℓ}.
> 1
3

Figure 27. – (Continued)

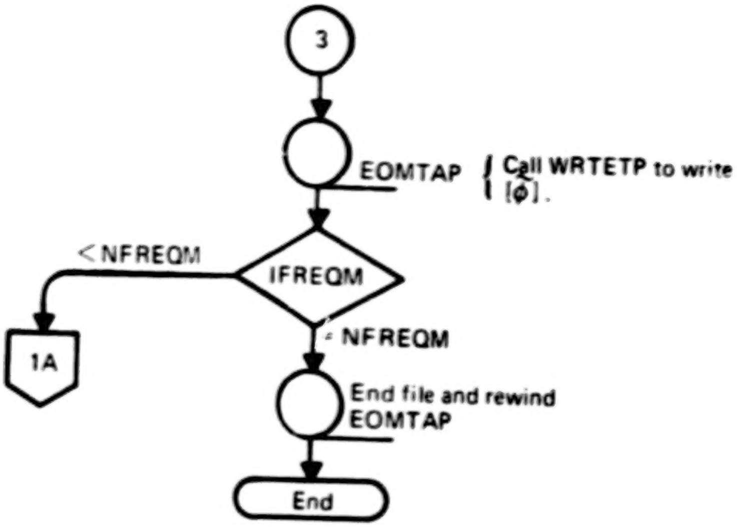


Figure 27. – (Concluded)

Table 22. – Routines Called by DLAEOM

```
OVERLAY(L217,4,11)

PROGRAM DLAEOM

----------------------------------------


CGNEOM

             ┌ FETAD♦
CYPM13       { FETDEL♦
             │ PRINTM♦
             │ READTP♦
             └ WRTETP♦
DELETR♦
FETAD♦
FETDEL♦
INITIR♦
PRINTM♦
PRNTCM♦
READTP♦
SCLMLT
SETMFL
STARTR♦
WRTETP♦


♦ indicates a routine from the DYLOFLEX
  alternate subroutine library
```

Analytical Steps of DLPRES

DLPRES performs its task in the following steps:

1. Print the message NOW IN DLPRES TO..., initialize the count of errors, and initialize the scratch file named S1L217.
2. Call overlay (L217,5,1), DLPCDS, to read the card input data directing the processing of Doublet Lattice (L216) generalized forces and unsteady pressures.
3. Call overlay (L217,5,2), DLPGEO, to process the Doublet Lattice (L216) geometry data and combine it with the card input data to prepare arrays directing the processing of steps 4 through 6.
4. Call overlay (L217,5,4) to generate the aerodynamic forces per reduced frequency and per mode.
5. Call overlay (L217,5,5) to sort the aerodynamic forces and write them onto EOMLOD by surface.
6. Call overlay (L217,5,6) to generate the equations of motion matrices and write them onto EOMTAP.
7. Close the scratch file S1L217 and return to the calling program.

The macro flow chart of this overlay is shown in figure 28.

The routines called are displayed in table 23.

The equations solved by DLPRES are summarized as follows:

$$[FR] = [FAC][\Sigma][A][\Delta CP]$$

$$[F_1] = q[FR]_{Real}$$

$$[F_2] = \frac{q}{\omega}[FR]_{Imaginary} \qquad (\text{if } \omega = 0,\ [F_2] = [0])$$

$$[FG] = \frac{iq}{\omega}[FR]_n \qquad (\text{if } \omega = 0,\ \frac{1}{v} \text{ replaces } -\frac{iq}{\omega})$$

where n indicates column n of $[FR]$

$$n = NTDEF \text{ if } \omega > 0$$
$$n = NPDEF \text{ if } \omega = 0$$

$$[M_4] = -2q[Q]_{Real}$$

$$[M_5] = -\frac{2q}{\omega}[Q]_{Imaginary} \qquad (\text{if } \omega = 0,\ [M_5] = [0])$$

$$\left\{\tilde{\phi}\right\} = \frac{2q}{\omega}\left\{Q_{Imaginary}\right\}_{NTDEF} - \frac{2iq}{\omega}\left\{Q_{Real}\right\}_{NTDEF} \qquad (\text{when } \omega > 0)$$

$$\left\{\tilde{\phi}\right\} = \frac{2q}{v}\left\{Q_{NPDEF}\right\} \qquad (\text{when } \omega = 0)$$

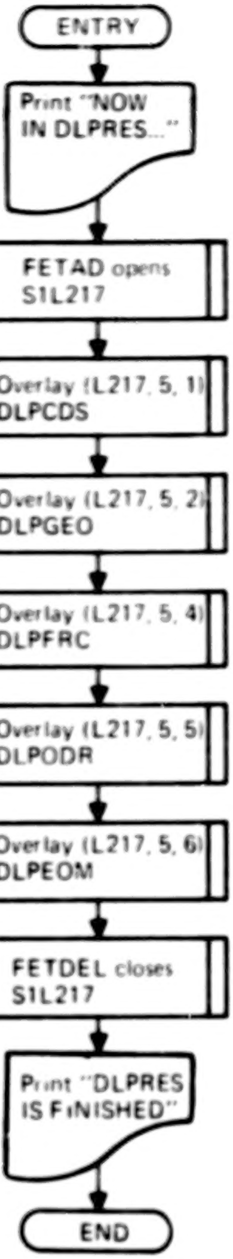

ENTRY
Print "NOW IN DLPRES..."
FETAD opens S1L217
Overlay (L217, 5, 1) DLPCDS
Overlay (L217, 5, 2) DLPGEO
Overlay (L217, 5, 4) DLPFRC
Overlay (L217, 5, 5) DLPODR
Overlay (L217, 5, 6) DLPEOM
FETDEL closes S1L217
Print "DLPRES IS FINISHED"
END

Figure 28. – Macro Flow Chart of Overlay (L217, 5, 0), DLPRES

Table 23. – Routines Called by DLPRES

```
OVERLAY(L217,5,0)

PROGRAM DLPRES

-------------------------------------------------------------


DLPCDS     OVERLAY(L217,5,1)

DLPEOM     OVERLAY(L217,5,6)

DLPFRC     OVERLAY(L217,5,4)

DLPGEO     OVERLAY(L217,5,2)

DLPCDR     OVERLAY(L217,5,5)

FETAD*

FETDEL*
```

```
* indicates routines from the DYLOFLEX
  alternate subroutine library
```

I/O Devices of DLPRES

DLPRES prints two messages on the output file; NOW IN DLPRES..., and DLPRES IS FINISHED... . All other file communication in DLPRES is performed by its secondary overlays. Figure 29 shows the files used in DLPRES' secondary overlays.

In subsections 3.5.1 through 3.5.5 the matrices read from and written onto each file are listed. (See sec. 6.4 to 6.5 of vol. I, *Engineering and Usage*, for detailed descriptions of the format and content of files for external communication.) Section 3.6.3 of this volume contains the same information for L217 (EOM)'s temporary scratch files.

3.5.1 OVERLAY(L217,5,1), DLPCDS

Purpose of DLPCDS

DLPCDS reads card input data directing the processing of Doublet Lattice (L216) generalized forces and unsteady pressures. (See card set 3.0 in vol. I of this document, *Engineering and Usage*.)

Analytical Steps of DLPCDS

DLPCDS performs its task in the following steps:

1. Initialize options and constants to their default values.
2. Read the constant card and extract RHO, VEL, NTDEF, and NPDEF.

   Repeat step 3 until an END card is read. Then, jump to step 4.

3. Read another data card, extract the keyword, and jump to the location which processes that card. The keywords are:

   SATAP
   NAETP
   NGETP
   EOMTAP
   EOMLOD
   CHECK
   PRINT
   SELECT
   SLENDER
   THIN
   CONTROL
   END

   - The keyword card CONTROL is recognized only after the THIN card.
   - The information from the THIN or SLENDER card is stored in the array IBDTAB and written onto the file S1L217.
   - The panels specified after a CONTROL card are stored in the array ICSTAB and written onto the file S1L217.

4. Write and end of file onto the file S1L217.

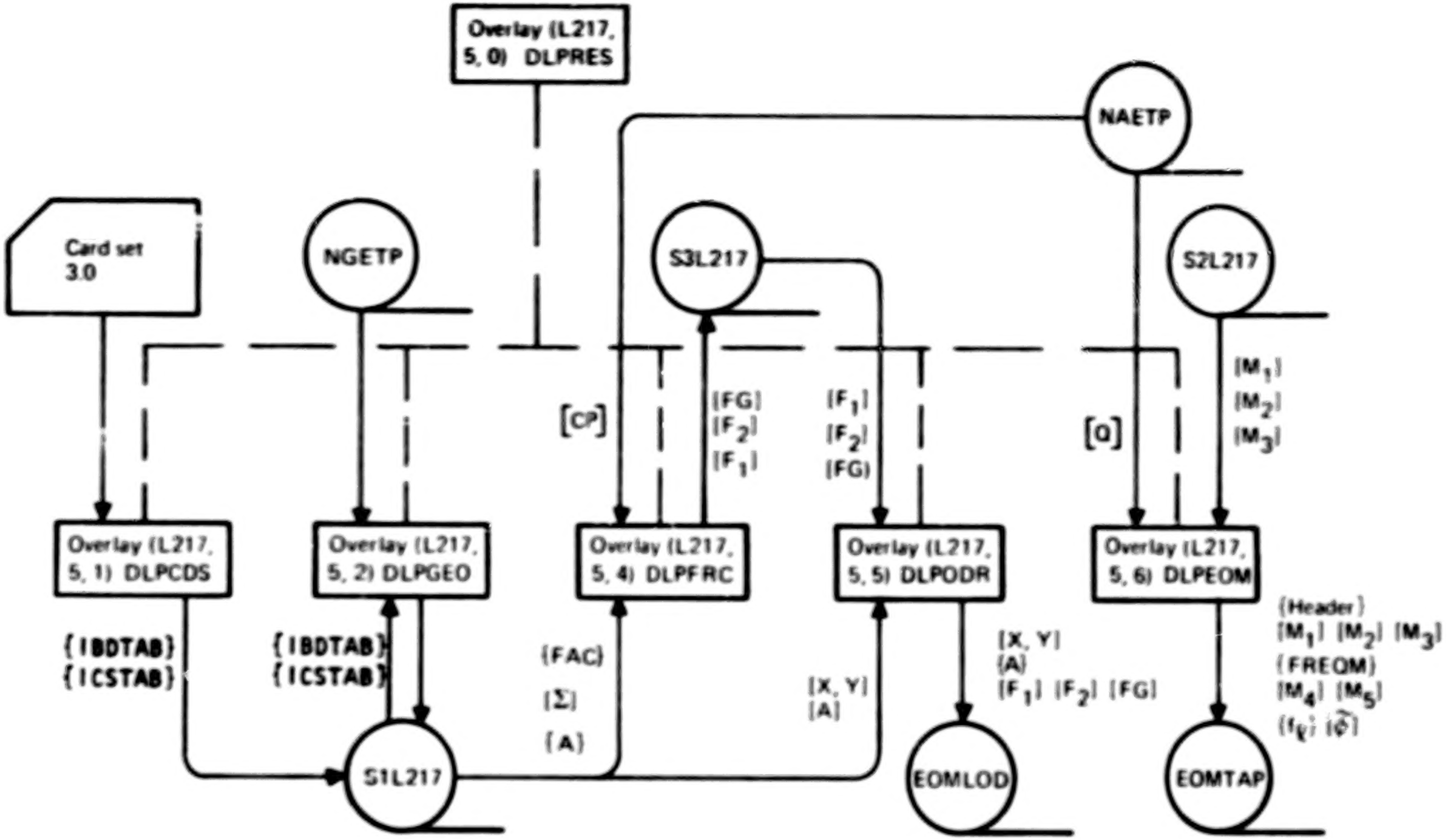


Figure 29. –Files Providing Input/Output to DLPRES Overlays

5. Return to the calling program.

The macro flow chart of this overlay is shown in figure 30.

The routines called are displayed in table 24.

I/O Devices of DLPCDS

DLPCDS reads all of the card input data directing the processing of Doublet Lattice (L216) generalized forces and unsteady pressures.

It prints all of the card images, additional descriptive comments, and diagnostics for all errors discovered.

DLPCDS writes arrays of surface data onto the file S1L217. The arrays are {IBDTAB} and {ICSTAB}. See section 3.6.3 for the exact format and content of S1L217.

3.5.2 OVERLAY(L217,5,2), DLPGEO

Purpose of DLPGEO

DLPGEO reads the Doublet Lattice (L216) geometry data from the file NGETP, combines it with the card input data read from S1L217, and prepares geometry arrays governing the calculation of aerodynamic forces. The arrays prepared are written onto the first logical file of S1L217 (see sec. 3.6.3).

Analytical Steps of DLPGEO

DLPGEO performs its tasks in the following steps:

1. Initialize geometry arrays and counters.
2. Call RDLGEO to read the Doublet Lattice (L216) geometry data from the file NGETP.

   Rewind S1L217, then repeat steps 3 through 5 for each body (thin or slender) defined via card input to DLPCDS; IBOD = 1, NBOD.

3. Read from S1L217 the array $\{IBDTAB\}_{IBOD}$, the card input data associated with the body. If control surfaces are attached to the body, the array {ICSTAB} is read from S1L217 to define the aerodynamic elements on each of the control surfaces.
4. Add to the array {ISURF} and build the IBOD portion of the array {IPNSRF}.

{ISURF}	A table of modal interpolation surfaces
{IPNSRF}	A table providing a correspondence between aerodynamic elements and modal interpolation surfaces

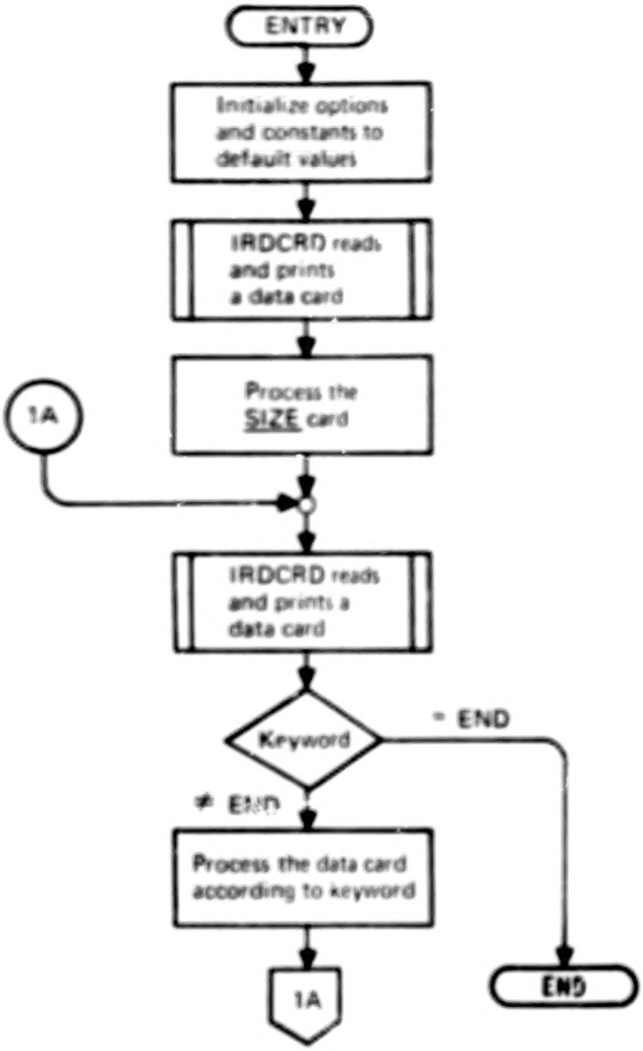

ENTRY
Initialize options and constants to default values
IRDCRD reads and prints a data card
Process the SIZE card
1A
IRDCRD reads and prints a data card
Keyword
= END
≠ END
Process the data card according to keyword
1A
END

Figure 30. —Macro Flow Chart of Overlay (L217, 5, 1), DLPCDS

Table 24. – Routines Called by DLPCDS

```
OVERLAY(L217,5,1)

PRORAM DLPCDS

-------------------------------------------------


FNDKEY◆

IRDCRD◆

NAMFIL◆

WRTETP◆
```

◆ indicates a routine from the **DYLOFLEX**
alternate subroutine library

5. Build the IBOD portion of the arrays:

$[\mathrm{F\mathring{A}C}]$	Used to double the force of slender body elements on the plane of symmetry
$[\mathrm{\mathring{S}F}]$	Used to double the force on elements off the plane of symmetry
{IGUSTZ}	Indicates that all elements are in gust gradual penetration zone number one. Gradual penetraton is not allowed in DLPRES.

6. Build the array [SIGMA] to define the correspondence between interference body elements and slender body segments. The [SIGMA] is used to add the interference body forces to the slender body segments.

7. Call PRTGFP to print the Doublet Lattice (L216) force point geometry.

8. Transform the reference axis coordinates of all bodies to local structural coordinates using the subroutine GTOLT.

9. Compress the geometry arrays from NTOTF to NAFP elements by eliminating all interference body element entries.

   NTOTF = Total number of focal points.

   NAFP = Number of aerodynamic force points on all slender and thin bodies.

10. Call WRTGEO to write geometry arrays onto the file S1L217 (see sec. 3.6.3).

11. Return to the calling program.

The macro flow chart of this overlay is shown in figure 31.

The routines called are displayed in table 25.

I/O Devices of DLPGEO

DLPGEO reads the Doublet Lattice (L216) geometry data from the file NGETP (see sec. 6.4.4 of vol. I).

DLPGEO reads the arrays {IBDTAB} and {ICSTAB} from S1L217. They contain the card input data read by DLPCDS.

DLPGEO prints the geometry arrays and then writes them onto the file S1L217.

3.5.3 OVERLAY(L217,5,4), DLPFRC

Purpose of DLPFRC

DLPFRC calculates the complex aerodynamic forces on the structural elements (the thin body boxes and slender body segments). Note that the interference body forces are

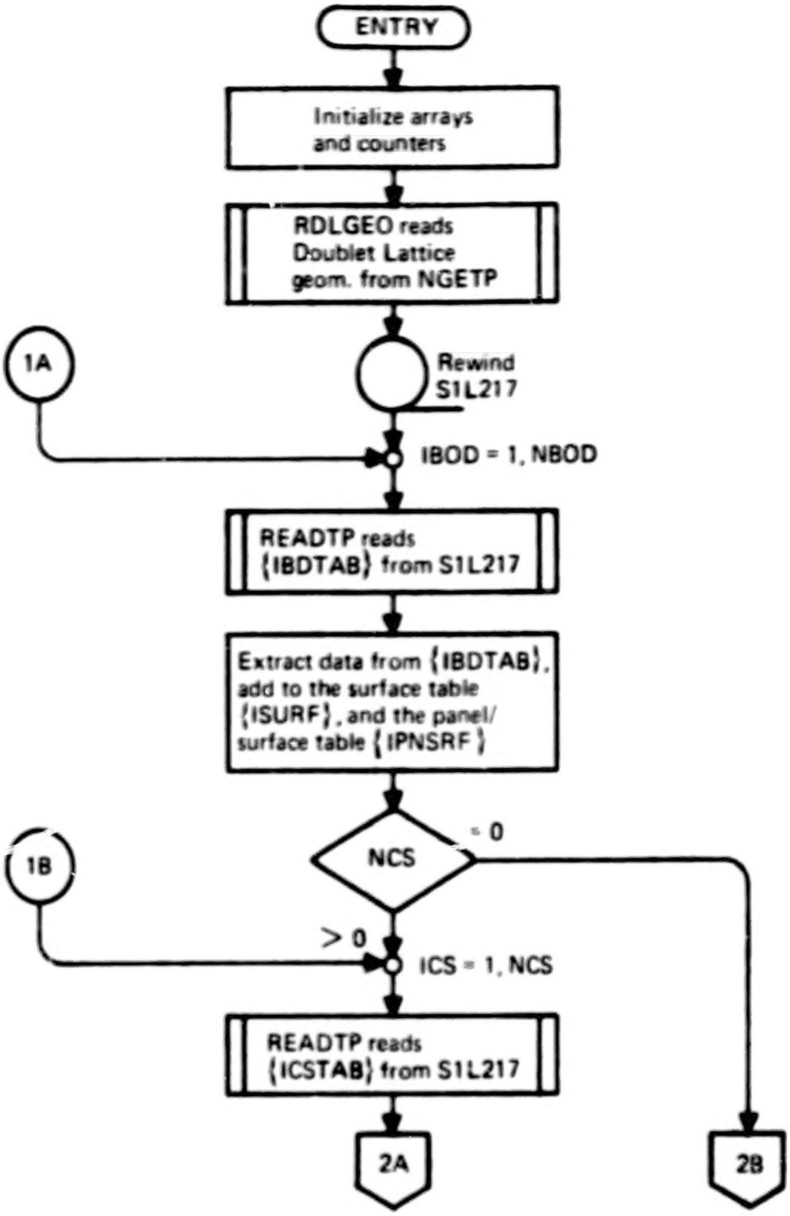

ENTRY
Initialize arrays and counters
RDLGEO reads Doublet Lattice geom. from NGETP
1A
Rewind S1L217
IBOD = 1, NBOD
READTP reads {IBDTAB} from S1L217
Extract data from {IBDTAB}, add to the surface table {ISURF}, and the panel/surface table {IPNSRF}
1B
NCS
= 0
> 0
ICS = 1, NCS
READTP reads {ICSTAB} from S1L217
2A
2B

Figure 31. —Macro Flow Chart of Overlay (L217, 5, 2), DLPGEO

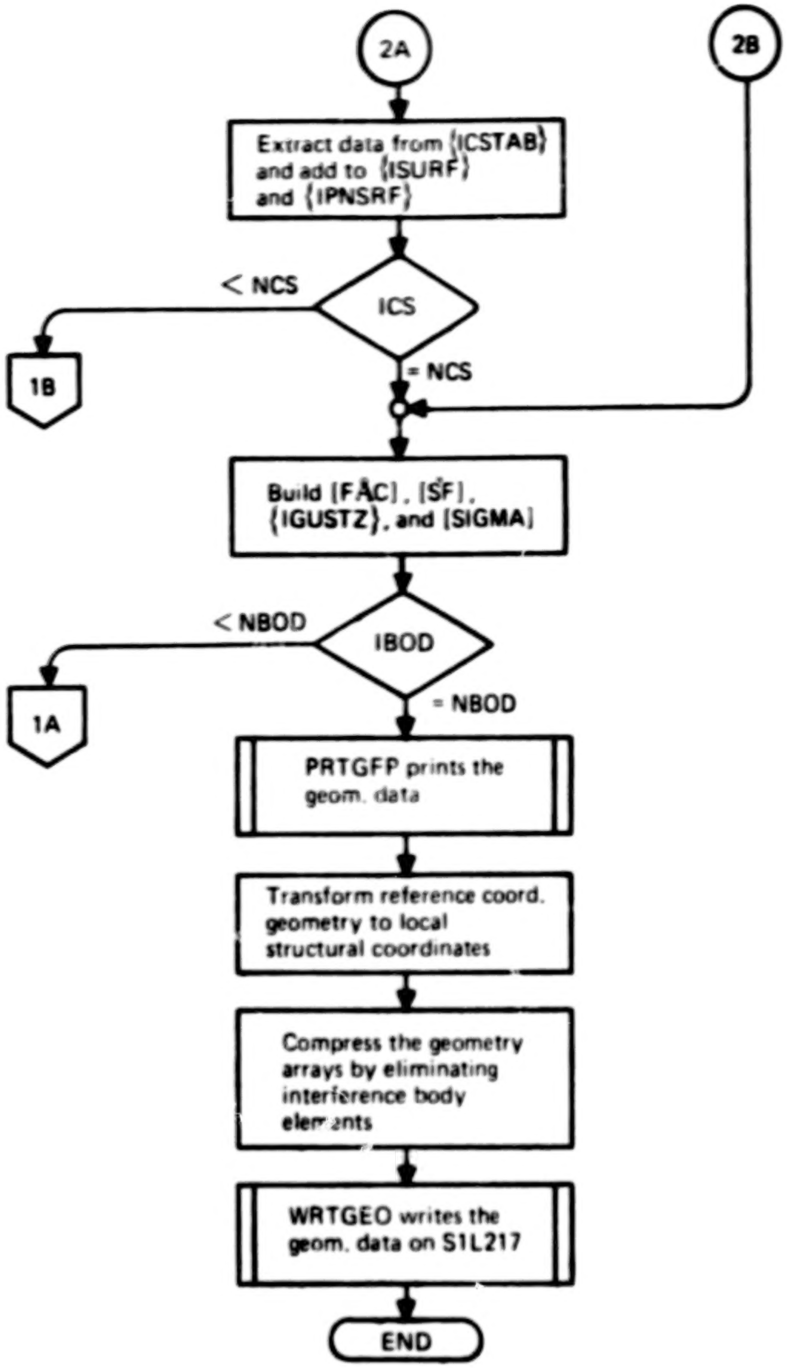

2A
2B
Extract data from {ICSTAB} and add to {ISURF} and {IPNSRF}
ICS
< NCS
= NCS
1B
Build [FAC], [SF], {IGUSTZ}, and [SIGMA]
IBOD
< NBOD
= NBOD
1A
PRTGFP prints the geom. data
Transform reference coord. geometry to local structural coordinates
Compress the geometry arrays by eliminating interference body elements
WRTGEO writes the geom. data on S1L217
END

Figure 31. —(Concluded)

Table 25. – Routines Called by DLPGEO

```
OVERLAY(L217,5,2)

PROGRAM DLPGEO

--------------------------------------------

GTOLT+

IRQL+

PRTGEO

RDLGEO  { FETAD+
        | FETDEL+
        | READTP+

WRTGEO    WRTETP+
```

+ indicates a routine from the **DYLOFLEX** alternate subroutine library included in the slender body segment forces by the summation matrix $[\Sigma]$ in the following equation:

$$[F_{12}]_k = [F\overset{\circ}{A}C][\overset{*}{\Sigma}][\overset{\circ}{A}][\Delta CP]_k$$

k = 1, NFREQM (the number of reduced frequencies)

Analytical Steps of DLPFRC

DLPFRC performs its task in the following steps:

1. Initialize VARDIM storage, arrays, and counters.
2. Read $[A]$, $[\Sigma]$, and $[F\overset{\circ}{A}C]$ from S1L217.
3. Read the $\{ACM\}$, the aerodynamic control matrix, from NAETP and extract the reduced frequencies.

   Repeat steps 4 through 7 for each reduced frequency.
4. Skip the $[F]$ and $[D]$ quasi-inverse matrices if they are on NAETP.

   Repeat steps 5 through 7 for each mode; IDOF = 1, NDOF.
5. Read $\{\Delta CP\}_{IDOF}$ from NAETP.
6. Call subroutines CEQAC, SUMFRC, and CEQAC again to form

$$\{F_{12}\}_{IDOF} = [F\overset{\circ}{A}C][\overset{\bullet}{\Sigma}][\overset{\circ}{A}]\{\Delta CP\}.$$

7. Call WRTETP to write $\{F_{12}\}_{IDOF}$ onto S3L217.
8. Close the scratch files and return to the calling program.

The macro flow chart of this overlay is shown in figure 32.

The routines called are displayed in table 26.

I/O Devices of DLPFRC

DLPFRC reads from the files:

NAETP	$\{ACM\}$	Aerodynamic control matrix
	$[\Delta CP]$	Complex unsteady pressure matrix by columns.

(See sec. 6.4.5 of vol. I and ref. 4 for a detailed description of NAETP contents.)

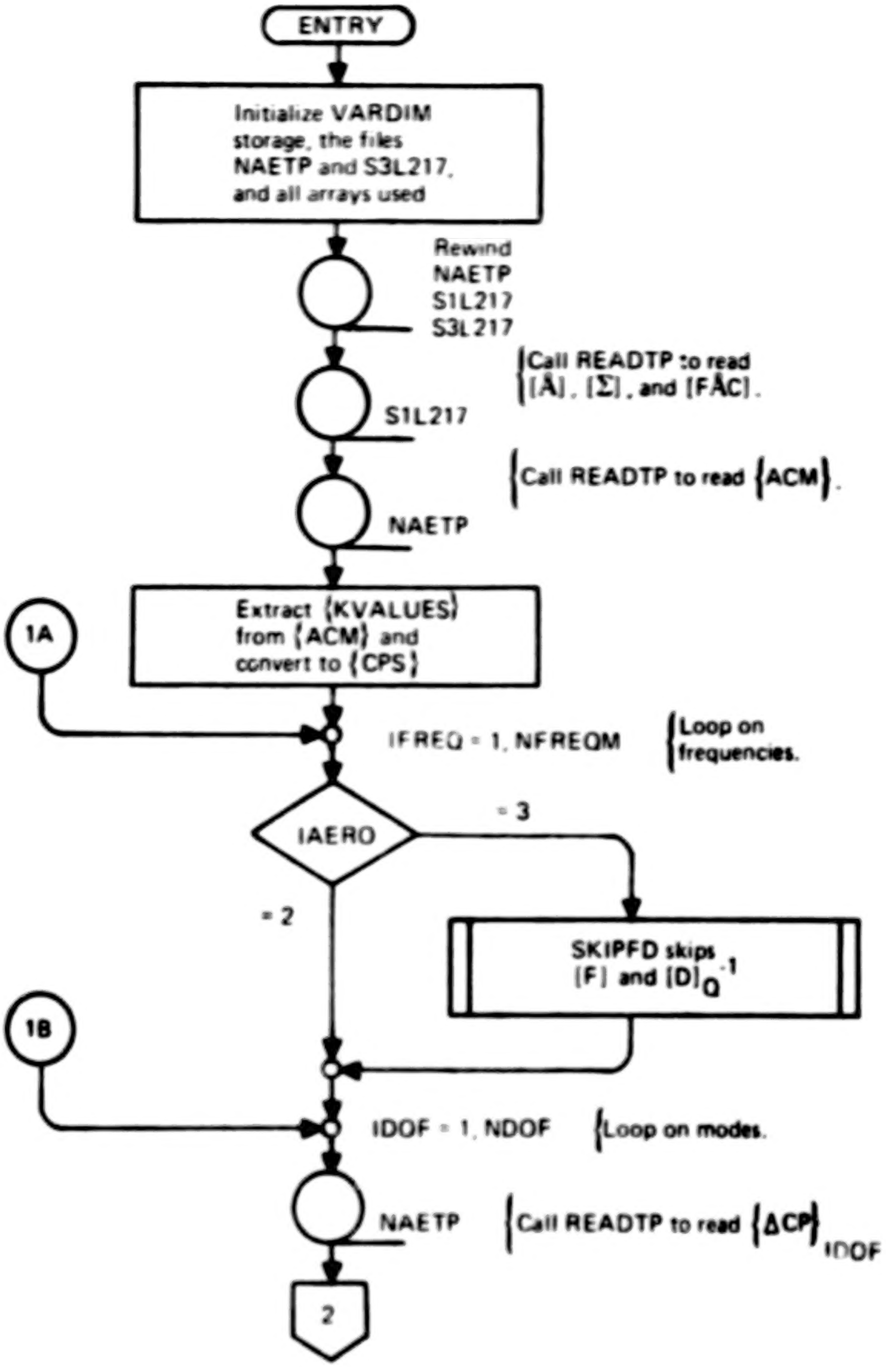

ENTRY
Initialize VARDIM storage, the files NAETP and S3L217, and all arrays used
Rewind NAETP S1L217 S3L217
Call READTP to read [Å], [Σ], and [FÅC].
S1L217
Call READTP to read {ACM}.
NAETP
1A
Extract {KVALUES} from {ACM} and convert to {CPS}
IFREQ = 1, NFREQM
Loop on frequencies.
IAERO
= 3
= 2
SKIPFD skips [F] and [D]$_Q^{-1}$
1B
IDOF = 1, NDOF
Loop on modes.
NAETP
Call READTP to read {ΔCP}$_{IDOF}$
2

Figure 32. —Macro Flow Chart of Overlay (L217, 5, 4), DLPFRC

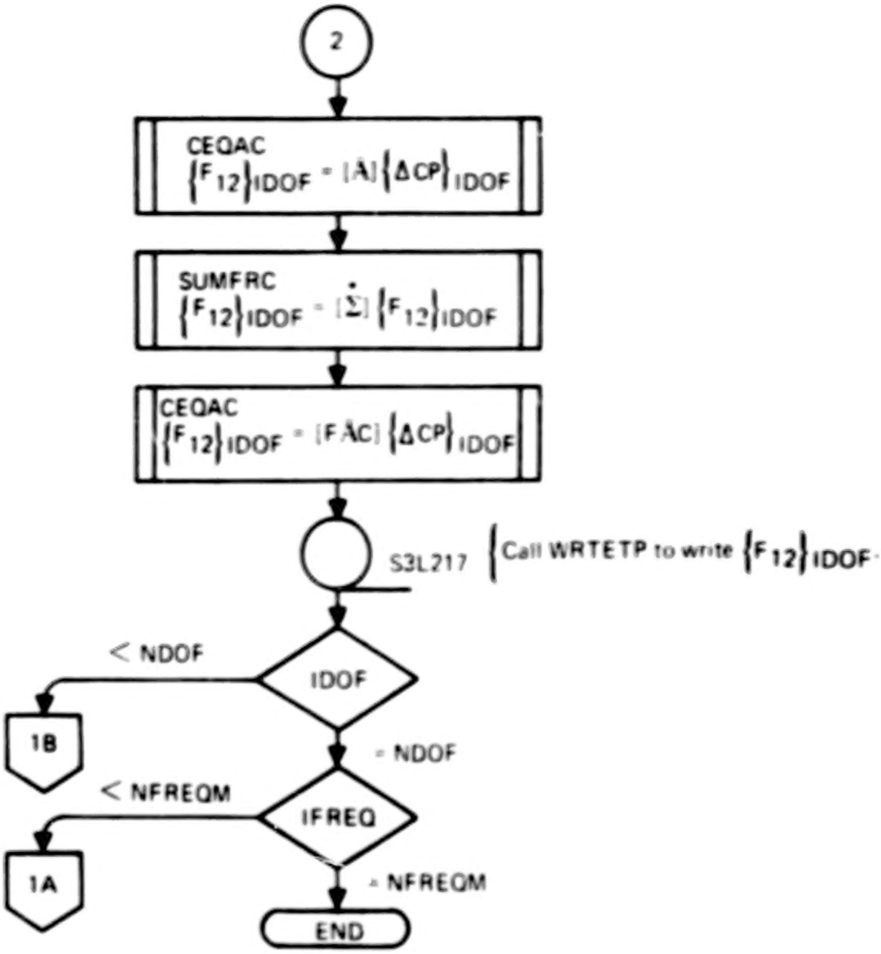

2
CEQAC
$\{F_{12}\}_{IDOF} = [\bar{A}]\{\Delta CP\}_{IDOF}$
SUMFRC
$\{F_{12}\}_{IDOF} = [\dot{\Sigma}]\{F_{12}\}_{IDOF}$
CEQAC
$\{F_{12}\}_{IDOF} = [F\bar{A}C]\{\Delta CP\}_{IDOF}$
S3L217
Call WRTETP to write $\{F_{12}\}_{IDOF}$
< NDOF
IDOF
1B
= NDOF
< NFREQM
IFREQ
1A
= NFREQM
END

Figure 32. –(Concluded)

Table 26. – Routines Called by DLPFRC

```
OVERLAY(L217,5,4)

PROGRAM DLPFRC

-----------------------------------------------------------


CEQAC

FETAD*

FETDEL*

INITIR*

READTP*

SETMFL

SKIPFD

STARTR*

SUMFRC

WRTETP*
```

* indicates a routine from the DYLOFLEX alternate subroutine library

S1L217	$[\dot{A}]$	Aerodynamic element areas
	$[\Sigma]$	Force summation matrix
	$[F\dot{A}C]$	Array to double the forces on slender body elements on the plane of symmetry

DLPFRC writes onto the file:

S3L217	$[F_{12}]$	Unsteady aerodynamic forces on thin body boxes and slender body segments Matrix is written by columns and repeated per reduced frequency

3.5.4 OVERLAY(L217,5,5), DLPODR

Purpose of DLPODR

DLPODR sorts the aerodynamic force matrices according to the interpolaton surface numbers specified for each element via card input data. The resulting surface force matrices are written onto the file EOMLOD.

The macro flow chart of this overlay is shown in figure 33.

The routines called are displayed in table 27.

I/O Devices of DLPODR

DLPODR reads from the file:

S1L217	{SURFTB}	Interpolation surface table
	{IPNSRF}	Panel/surface correspondence table
	{X}	X-coordinates of aerodynamic force points
	{Y}	Y-coordinates of aerodynamic force points
S3L217	{A}	Aero element areas
	$[F_{12}]$	Complex aerodynamic forces at thin and slender body force points

DLPODR writes on EOMLOD for each interpolation surface IS the following matrices:

$[X,Y]_{IS}$	Local coordinates of the surface's force points
$\{A\}_{IS}$	Areas of surface IS elements
$[F_1]$	Real part of aero forces on surface IS
$[F_2]$	Imaginary part of aero forces on surface IS
[FG]	Complex matrix of gust forces on surface IS

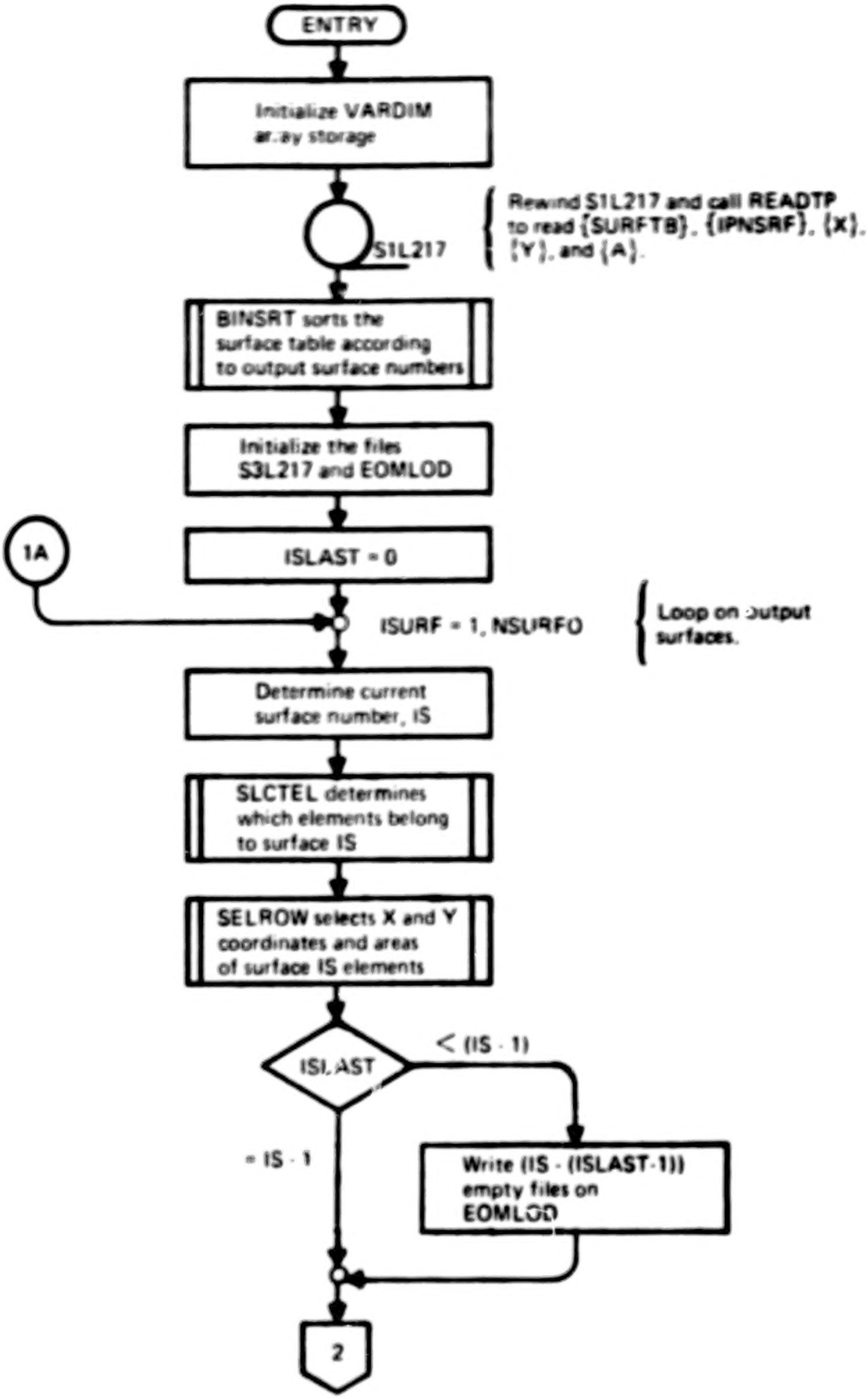

ENTRY
Initialize VARDIM array storage
S1L217
Rewind S1L217 and call READTP to read {SURFTB}, {IPNSRF}, {X}, {Y}, and {A}.
BINSRT sorts the surface table according to output surface numbers
Initialize the files S3L217 and EOMLOD
1A
ISLAST = 0
ISURF = 1, NSURFO
Loop on output surfaces.
Determine current surface number, IS
SLCTEL determines which elements belong to surface IS
SELROW selects X and Y coordinates and areas of surface IS elements
ISLAST
< (IS - 1)
= IS - 1
Write (IS - (ISLAST-1)) empty files on EOMLOD
2

Figure 33. —Macro Flow Chart of Overlay (L217, 5, 5), DLPODR

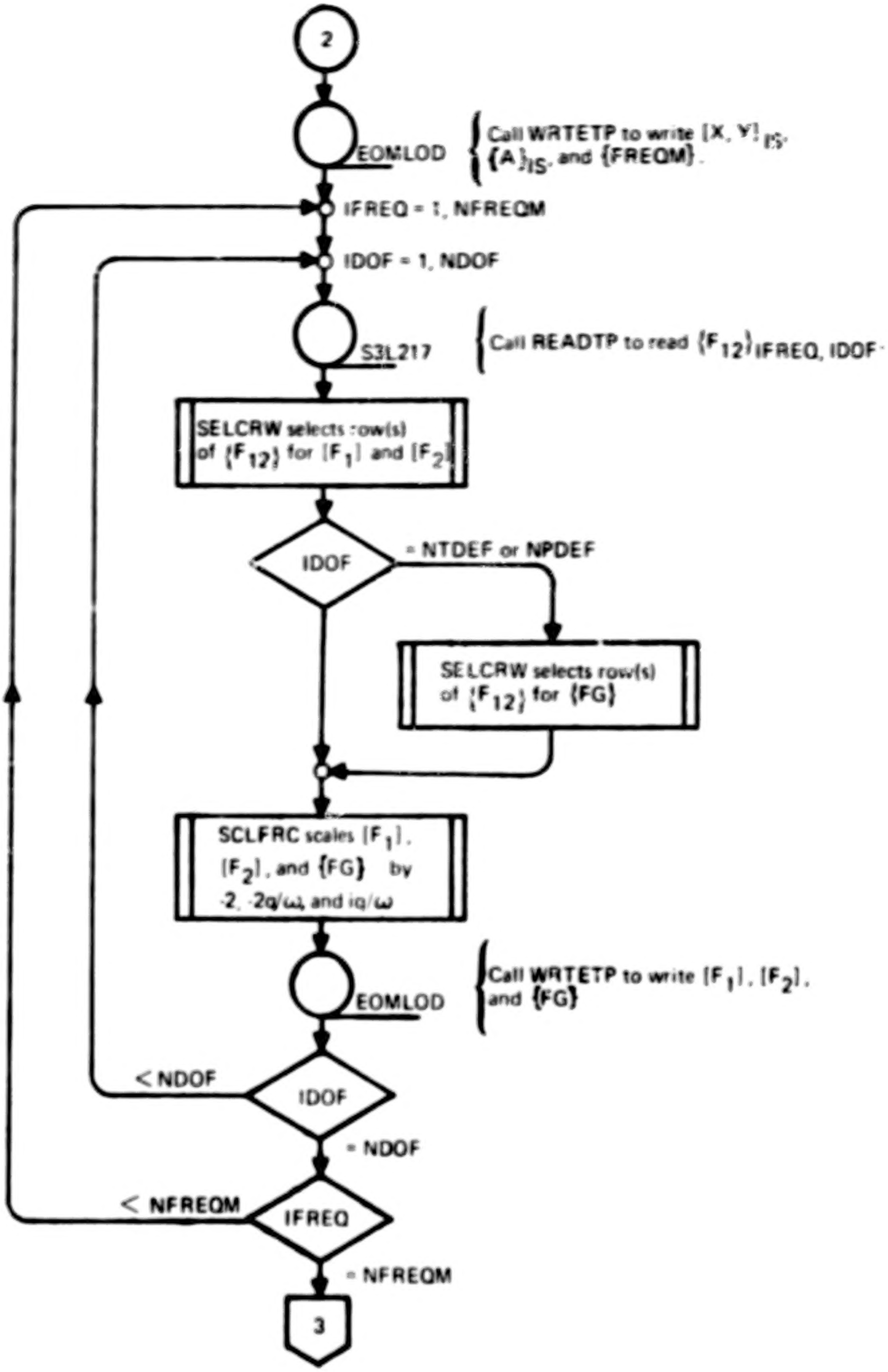

2
EOMLOD
Call WRTETP to write [X, Y]$_{IS}$, {A}$_{IS}$, and {FREQM}.
IFREQ = 1, NFREQM
IDOF = 1, NDOF
S3L217
Call READTP to read {F$_{12}$}$_{IFREQ, IDOF}$.
SELCRW selects row(s) of {F$_{12}$} for [F$_1$] and [F$_2$]
IDOF
= NTDEF or NPDEF
SELCRW selects row(s) of {F$_{12}$} for {FG}
SCLFRC scales [F$_1$], [F$_2$], and {FG} by -2, -2q/ω, and iq/ω
EOMLOD
Call WRTETP to write [F$_1$], [F$_2$], and {FG}
< NDOF
IDOF
= NDOF
< NFREQM
IFREQ
= NFREQM
3

Figure 33. –(Continued)

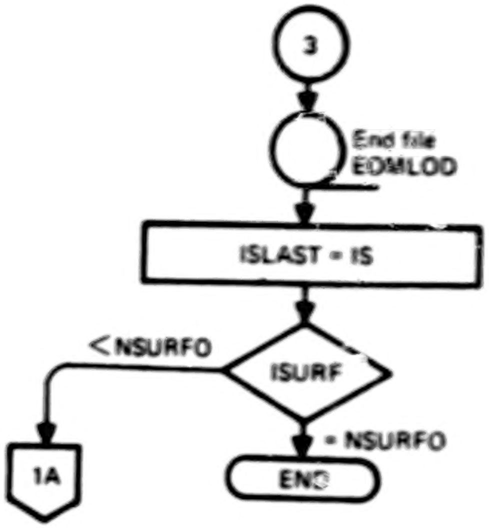


Figure 33. – (Concluded)

Table 27. – Routines Called by DLPODR

```
OVERLAY(L217,5,5)

PROGRAM DLPODR

-----------------------------------------------


BINSRT

DELETR*

FETAD*

FETDEL*

INITIR*

PRINTM*

PRNTCM*

READTP*

SCLFRC

SELCRW

SELROW

SETMFL

SLCTEL

STARTR*

WRTETP*




* indicates routines from the DYLOFLEX

  alternate subroutine library
```

3.5.5 OVERLAY(L217,5,6), DLPEOM

Purpose of DLPEOM

DLPEOM generates the file EOMTAP containing the equations of motion coefficient matrices. The aerodynamic matrices ($[M_4]$, $[M_5]$, and $[\tilde{\phi}]$) are based upon the Doublet Lattice (L216) (ref. 4) generalized forces.

$$[M_4] \quad = -2[Q_{Real}]$$

$$[M_5] \quad = -\frac{2}{\omega}[Q_{Imaginary}]$$

$$[\tilde{\phi}] \quad = \frac{2q}{v}\{Q_{Real}\}NPDEF \text{ (when } \omega = 0.0)$$

$$[\tilde{\phi}] \quad = \frac{2q}{\omega}\left(\{Q_{Imaginary}\}NTDEF - i\,\{Q_{Real}\}NTDEF\right) \text{(when } \omega \neq 0.0)$$

where $[Q]$ = the generalized air force matrix from Doublet Lattice (L216)

The macro flow chart of this overlay is shown in figure 34.

The routines called are displayed in table 28.

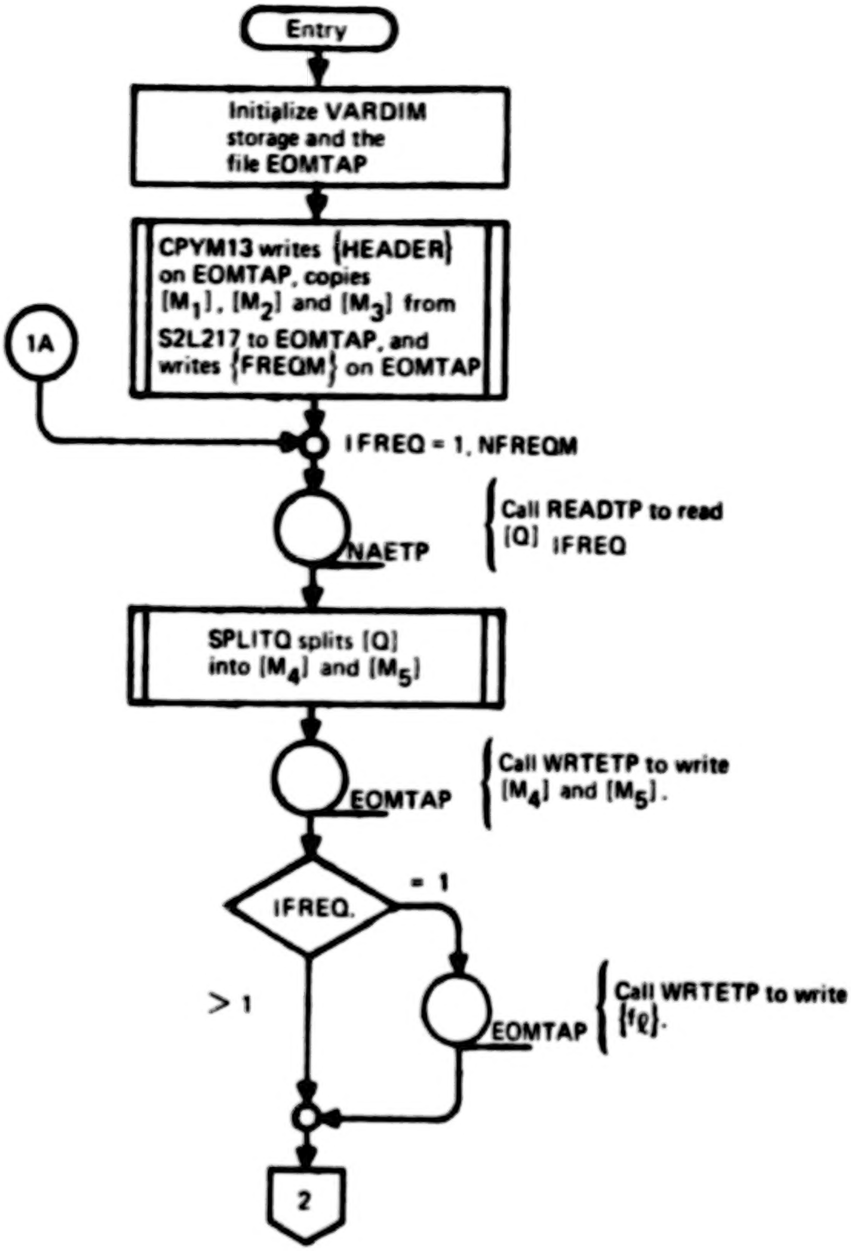
I/O Devices of DLPEOM

DLPEOM reads from the files:

NAETP	$[Q]$	Complex matrix of generalized forces from Doublet Lattice (ref. 4)
S2L217	$[M_1]$	Generalized stiffness matrix
	$[\overset{\circ}{M}_2]$	Generalized damping matrix (optional)
	$[M_3]$	Generalized mass matrix

DLPEOM writes onto the file

EOMTAP	{HEADER}	DYLOFLEX header matrix introducing following arrays
	$[M_1]$	
	$[\overset{\circ}{M}_2]$	From S2L217 above
	$[M_3]$	
	{FREQM}	Frequencies at which aerodynamics are defined
	$\{M_4\}$	Aerodynamic force matrices
	$\{M_5\}$	
	$\{f_\ell\}$	Distance to gust zones
	$[\tilde{\phi}]$	Gust force matrix



Entry
Initialize VARDIM storage and the file EOMTAP
CPYM13 writes {HEADER} on EOMTAP, copies [M1], [M2] and [M3] from S2L217 to EOMTAP, and writes {FREQM} on EOMTAP
1A
IFREQ = 1, NFREQM
NAETP
Call READTP to read [Q] IFREQ
SPLITQ splits [Q] into [M4] and [M5]
EOMTAP
Call WRTETP to write [M4] and [M5].
IFREQ
= 1
> 1
EOMTAP
Call WRTETP to write {fℓ}.
2

Figure 34. —Macro Flow Chart of Overlay (L217, 5, 6), DLPEOM

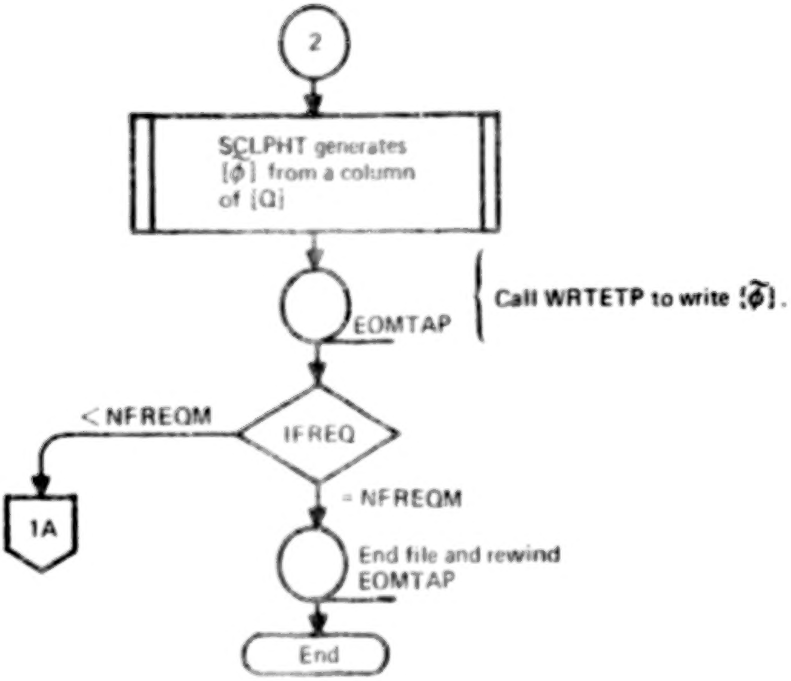

2
SCLPHT generates {φ} from a column of {Q}
EOMTAP
Call WRTETP to write {φ̃}.
< NFREQM
IFREQ
1A
= NFREQM
End file and rewind EOMTAP
End

Figure 34. – (Concluded)

Table 28. – Routines Called by DLPEOM

```
OVERLAY(L217,5,6)

PROGRAM DLPEOM

-----------------------------------------------
CPYM13  ⎧ FETAD*
        ⎪
        ⎪ FETDEL*
        ⎪
        ⎨ PRINTM*
        ⎪
        ⎪ READTP*
        ⎪
        ⎩ WRTETP*

DELETR*

FETAD*

FETDEL*

INITIR*

PRINTM*

PRNTCM*

READTP*

SCLPHT

SETMFL

SKIPFD

SPLITQ

STARTR*

WRTETP*

* indicates a routine from the DYLOFLEX
  alternate subroutine library
```

3.6 DATA BASES

The program's data bases include input and output files plus internal scratch (temporary) storage files and common blocks.

3.6.1 INPUT DATA

Data is input to the program in two forms; data cards and magnetic files.

Card Input Data

For a complete description of L217 (EOM) card input data, see section 6.3 in volume I of this document.

Magnetic File Input Data

For a complete description of L217 (EOM) disk or tape input data, see section 6.4 in volume I of this document.

The files read are:

KTAPE(GSTIF)		NGETP	from L216 (DUBFLX)
MTAPE(GMASS)		GDTAPE	from FLEXSTAB
SATAP	from L215 (INTERP)	SDSSTP	from FLEXSTAB
NAETP	from L216(DUBFLX)		

3.6.2 OUTPUT DATA

The results of a L217 (EOM) run will be printed, and written on magnetic files.

Printed Output Data

For a complete description of the printed output data, see section 6.5.1 in volume I of this document.

Magnetic File Output Data

For a complete description of L217 (EOM) disk or tape output data, see section 6.5.2 in volume I of this document. The files written are:

EOMTAP
EOMLOD

3.6.3 INTERNAL DATA

Two methods are used to pass data from one portion of the program to another. They are labelled common blocks and scratch (temporary) storage disk files.

Magnetic Disk Files

L217 (EOM) uses 10 disk files for temporary (scratch) storage of data. The files are:

S1L217, S2L217
S3L217
NTP3, NTP4, NTP5, MT, NIN, NOUT, and NATAPE

The first two files are used in all L217 primary overlays. The S3L217 is used in all aerodynamic primary overlays. The other files are used only in DLAIC when solving the system of complex simultaneous equations. All scratch files are released before L217 (EOM) terminates execution.

The first three files are always written with the subroutine WRTETP and read with the subroutine READTP. The READTP/WRTETP format is described in reference 1. The other files are written with unformatted FORTRAN write statements.

S1L217

The scratch file named S1L217 may contain several logical files of data, each terminated by an end of file (EOF). The data on S1L217 is always in the READTP/WRTETP format. The matrices existing on the file vary according to which overlay was executed last (see figs. 35 through 39).

The following matrices are written onto S1L217 inside STRUCT's secondary overlays:

[CSDATA] Data for a control surface adding freedoms. Each row of CSDATA represents a control suface node and contains six numbers as input on card 2.9.1.

$$\left.\begin{matrix}X\\Y\\Z\end{matrix}\right\}\text{ Coordinates of control surface node}$$

m = Mass

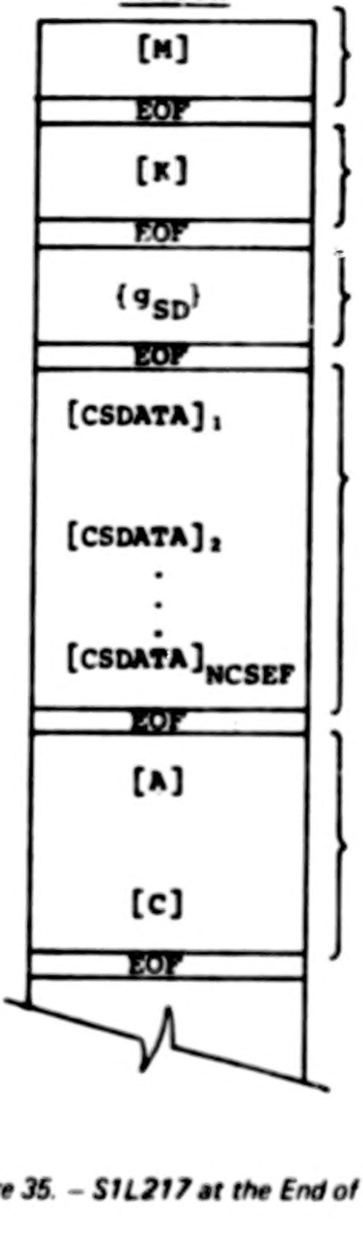
I_y = Moment of inertia about local y-axis
I_x = Moment of inertia about local x-axis

$$[A] = [\phi_{CS}]^T[M\mathring{C}S][\phi_{ST}]$$

$$[C] = [\phi_{CS}]^T[M\mathring{C}S][\phi_{CS}]$$

All of the data listed in figure 35 is released just before overlay (L217,2,0), STRUCT terminates execution.

The S1L217 written by overlays (L217,3,1), FLXCDS
(L217,4,1), DLACDS
(L217,5,1), DLPCDS



Matrix Size	Matrix	
$NDOF_{ST}$ X $NDOF_{ST}$	[M]	Original generalized mass matrix written in RSTRCT only if read from cards.
	EOF	
$NDOF_{ST}$ X $NDOF_{ST}$	[K]	Original generalized stiffness matrix written in RSTRCT only if read from cards.
	EOF	
$NDOF_{ST}$ x 1	$\{g_{SD}\}$	Damping factors written in RSTRCT only if read from cards.
	EOF	
$NNODE_1$ X 6	$[CSDATA]_1$	Written in RSTRCT only if cards specifying control surface freedoms were read.
$NNODE_2$ X 6	$[CSDATA]_2$	
. . .	. . .	
$NNODE_{NCSEF}$ X 6	$[CSDATA]_{NCSEF}$	NCSEF = number of control surfaces adding freedoms
	EOF	
$NDOF_{CS}$ X $NDOF_{ST}$	[A]	Written in FORMAC only if control surface freedoms added.
$NDOF_{CS}$ X $NDOF_{CS}$	[C]	
	EOF	

Figure 35. – S1L217 at the End of Overlay (L217,2,3,), Form13

Matrix Size	Matrix	Description
NSURF X 1	{SURFTB}	Surface Table
NAFP X 1	{IPNSRF}	Force Point/Surface Table
NAFP X 1	{X}	Force Point x-coordinates
NAFP X 1	{Y}	Force Point y-coordinates
NACP X 1	{IPNSCP}	Control Point/Surface Table
NACP X 1	{XCP}	Control Point x-coordinates
NACP X 1	{YCP}	Control Point y-coordinates
NTOTF X 1	$\{\mathring{A}\}$	Areas of all aero elements
NTOTF X 4	[SIGMA]	Force summation matrix ([Σ])
NAFP X 1	$\{\mathring{FAC}\}$	Array of 1's and 2's to double force of slender body elements on the P.O.S.
NACP X 1	{GC}	Array of integer numbers indicating the gust zone of each control point.
NAFP X 1	$\{\mathring{SF}\}$	Array of 1's and 2's to double force of elements off the P.O.S.
NACP X 1	$\{\mathring{RG}\}^{\bullet\bullet}$	Gust rotation matrix
NSBFP X 1	$\{\mathring{R}\}^{\bullet}$	Slender body segment midpoint radii
NSBFP X 1	$\{\mathring{R}'\}^{\bullet}$	Slender body segment midpoint radius slopes.
	EOF	

• Meaningless with FLEXSTAB data

••Meaningless except with Doublet Lattice (L216) AIC data

Figure 36. – S1L217 Logical File 1 After a Geometry Overlay

Matrix Size	Matrix	Description
NACP X IPSIZE	$[\phi_{CP}]$	Modal deflections at control points
NACP X IPSIZE	$[\phi'_{CP}]$	Modal slopes at control points
NAFP X IPSIZE	$[\phi_{FP}]$	Modal deflections at force points
	EOF	
		The three matrices are repeated per partition of the total number of modes with IPSIZE $\leq$ 20

Figure 37. – S1L217 Logical File 2 After Overlay (L217,3,3), FLXMOD

Matrix Size	Matrix	Description
NSBCP X IPSIZE	$[\phi_{CP}]_{SB}$	Modal deflections at SB control points
NSBCP X IPSIZE	$[\phi'_{CP}]_{SB}$	Modal slopes at SB control points
NSBCP X IPSIZE	$[\phi''_{CP}]_{SB}$	2nd deriative of modal deflections at SB control points.
NTBCP X IPSIZE	$[\phi_{CP}]_{TB}$	Modal deflections at TB control points
NTBCP X IPSIZE	$[\phi'_{CP}]_{TB}$	Modal slopes at TB control points
NAFP X IPSIZE	$[\phi_{FP}]$	Modal deflections at all force points
	EOF	The matrices are repeated per partition of the total number of modes with IPSIZE ≤ 20

Figure 38. -- S1L217 Logical File 2 After Overlay (L217,4,3), DLAMOD

Matrix Size	Matrix	Description
NSBFP2 X NSBFP	$[CP_{SB}]$	Slender body pressure coefficients
NSBFP2 X NGCP	$[CPG_{SB}]$	Slender body gust pressure coefficients
2 X NDOF	$\lfloor W_{TB} \rfloor$	Normalwash on thin body element 1
2 X NGCP	$\lfloor WG_{TB} \rfloor$	Gust normalwash on thin body element 1
2 X NDOF	$\lfloor W_{TB} \rfloor$	2
2 X NGCP	$\lfloor WG_{TB} \rfloor$	2
⋮	⋮	⋮
2 X NDOF	$\lfloor W_{TB} \rfloor_{NTBFP}$	Normalwash on thin body element NTBFP
2 X NGCP	$\lfloor WG_{TB} \rfloor_{NTBFP}$	Gust normalwash on thin body element NTBFP
	EOF	Note: Because all of these arrays are complex the number of rows written onto S1L217 were doubled.

Figure 39. – S1L217 Logical File 3 After Overlay (L217,4,4), CPANDW

The card input data for all three aerodynamic paths is read from cards and stored on S1L217 in the same fashion. The file will contain the array {IBDTAB} for each thin or slender body specified by a card. The array {IBDTAB} contains seven elements:

Element		Description
1	ISY	= Interpolation surface number for the body's Y-motion (in the left most 30 bits)
	ISZ	= Interpolation surface number for the body's Z-motion (in the right most 30 bits)
2	ISTORE	= Surface number in which the body's forces will be placed when written on EOMLOD
3	XSHIFT	Geometric shift values
4	YSHIFT	
5	ZSHIFT	
6	NCS	= Number of control surfaces attached to the surface ($= 0$ for slender bodies and ≤ 10 for thin bodies)
7	IBDTYP	= Body type code (1 = slender body and 3 = thin body)

If NCS > 0, the body table array will be followed immediately by NCS arrays {ICSTAB}. The {ICSTAB} will contain the numbers of the thin body elements contained in the control surface. Note that the elements are numbered relative to each thin body, not for the entire structure.

The S1L217 logical file 1 written by overlays (L217,3,2), FLXGEO
(L217,4,2), DLAGEO
(L217,5,2), DLPGEO

Although the geometry input data for the three aerodynamic paths is different, the geometry stored on the first logical file of S1L217 by the geometry processors is in exactly the same format.

Figure 36 displays the matrices written on the file. The following descriptions supplement the short ones in the figure.

{SURFTB}

Each element of SURFTB is an integer representing a modal interpolation surface used in L217 (EOM).

$SURFTB_i$	$= 10^6$	• IS	Interpolation surface number
	$+ 10^3$	• ISTORE	Output surface number
	$+ 10^2$	• ITYPE	Body type code (1 = SB, 3 = TB)
	$+ 10$	• NMOT	Number of motion types for Body (1 = TZ, 2 = TY, 3 = both)
	+	IPOS	Plane of symmetry code (0 = off, 1 = on)

{IPNSRF} and {IPNSCP}

Each element of IPNSRF/IPNSCP is an integer representing a force/control point.

IPNSRF $= 10^6$ • IS
$+ 10^3$ • ISTORE
$+ 10^2$ • ITYPE
$+$ IPOS

{RG}

The gust rotation matrix has elements for all thin body and slender body control points.

For a thin body element:

Symmetric analysis $RG_i = \cos\gamma_i$

Anti-symmetric analysis $RG_i = -\sin\gamma_i$

Where γ_i is the element's dihedral angle

For a slender body element:

Symmetric analysis

Y-motion element $RG_i = 0.0$

Z-motion element $RG_i = 1.0$

Anti-symmetric analysis

Y-motion element $RG_i = 1.0$

Z-motion element $RG_i = 0.0$

[SIGMA]

Each row i of [SIGMA] (also known as $[\Sigma]$) indicates where the forces on aerodynamic element i are to be stored. The primary purpose of SIGMA is to add the interference body forces to the slender body forces. However, in the following paragraph, other factors are included in SIGMA for a FLEXSTAB AIC data case.

SIGMA(i,1) - Indicates which force point will receive the **SIGMA(i,2)** fraction of the force on aero element i

SIGMA(i,3) - Indicates which force point will receive the **SIGMA(i,4)** fraction of the force on aero element i

For a FLEXSTAB AIC data case, the following ΔCp factors are included in the second and fourth columns of SIGMA:

$\pi/2$ for slender body Y-motion elements

$-\pi/2$ for slender body Z-motion elements

-1.0 for interference body elements

1.0 for thin body elements

The S1L217 logical file 2 written by overlays (L217,2,3), FLXMOD
(L217,4,3), DLAMOD

The modal deflections and slopes calculated by FLXMOD and DLAMOD are written onto the second logical file of S1L217.

Overlay (L217,4,4), CPANDW, writes the intermediate arrays onto the third logical file of S1L217 (fig. 39).

S2L217

S2L217 is written by overlay (L217,2,0), STRUCT (see fig. 40). It will contain the generalized structural matrices after STRUCT is finished. Actually, they are written in the secondary overlay, overlay (L217,2,3), FORM13. The matrices are written in the READTP/WRTETP format.

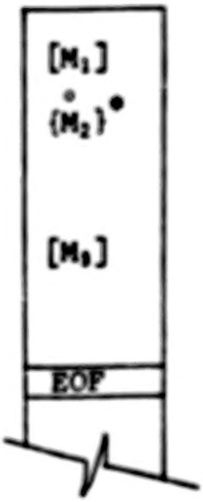
S3L217

Overlays (L217,3,4), FLXFRC; (L217,4,7), DLAFRC; and (L217,5,4), DLPFRC all write the unsteady aerodynamic forces onto S3L217 with the subroutine WRTETP. However, the exact content and format is different for each. FLXFRC output is displayed in figure 41. In DLAFRC, the entire logical file (including the end of file) is repeated for each frequency at which the aerodynamics are defined. Because the force matrices [FR] and [FG] are complex, they are written onto S3L217 with NAFP2 rows where NAFP2 = 2 * NAFP (see fig. 42).

In DLPFRC, because the force matrices $[F_{12}]_k$; k = 1, NFREQM are complex, the matrix columns are written onto S3L217 with NAFP2 rows where NAFP2 = 2 * NAFP. The columns of $[F_{12}]_1$ are written first followed by the columns of $[F_{12}]_2$, etc. See figure 43.

NTP3

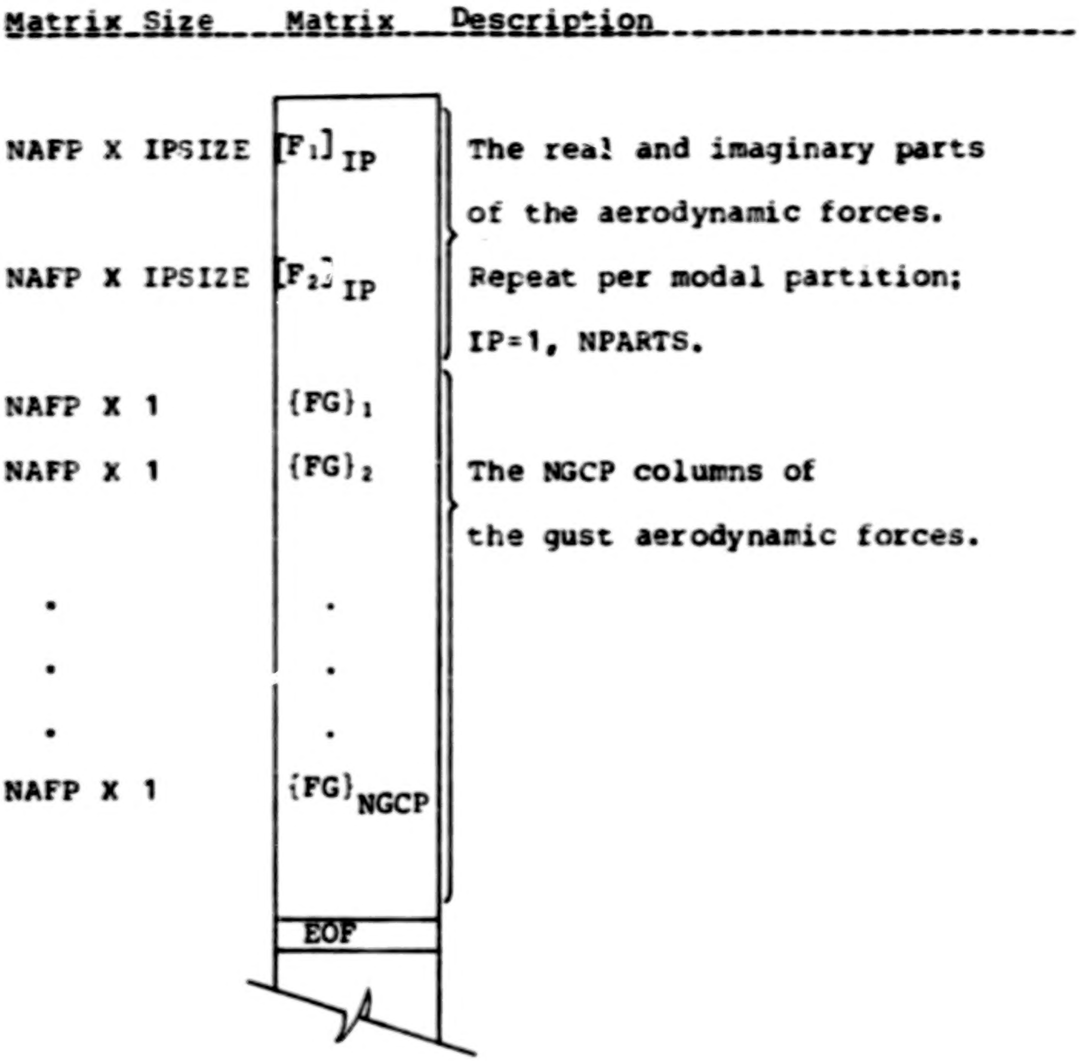
FORMWS calls WRTETP to write the rows of [W], the augmented normalwash, and [WG]; the augmented gust normalwash, onto NTP3 (see fig. 44) as they are formulated. FORMWS later reads the rows back into core and writes the same data onto NTP4 by columns with FORTRAN unformatted write statements.



Matrix Size	Matrix	Description
NDOF X NDOF	$[M_1]$	Generalized stifness matrix
1 X NDOF	$\{\dot{M}_2\}^*$	Diagonal elements of the generalized damping matrix.
NDOF X NDOF	$[M_3]$	Generalized mass matrix

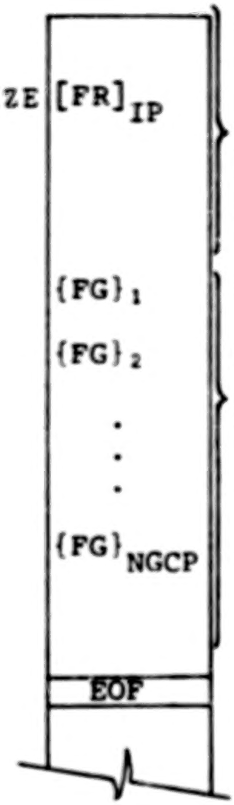
$^*M_2$ is present if and only if structural damping was specified with card 2.8.

Figure 40. – S2L217 After Overlay (L217,2,0), STRUCT



Matrix Size	Matrix	Description
NAFP X IPSIZE	$[F_1]_{IP}$	The real and imaginary parts of the aerodynamic forces. Repeat per modal partition; IP=1, NPARTS.
NAFP X IPSIZE	$[F_2]_{IP}$	
NAFP X 1	$\{FG\}_1$	The NGCP columns of the gust aerodynamic forces.
NAFP X 1	$\{FG\}_2$	
.	.	
.	.	
.	.	
NAFP X 1	$\{FG\}_{NGCP}$	
	EOF	

Figure 41. – S3L217 After Overlay (L217,3,4), FLXFRC



Matrix Size	Matrix	Description
NAFP2 X IPSIZE	$[FR]_{IP}$	The aerodynamic forces on Thin and Slender Body force points. Repeat per modal partition; IP=1, NPARTS.
NAFP2 X 1	$\{FG\}_1$	The NGCP columns of the gust aerodynamic forces on Thin and Slender Body force points.
NAFP2 X 1	$\{FG\}_2$	
.	.	
.	.	
.	.	
NAFP2 X 1	$\{FG\}_{NGCP}$	

Figure 42. – S3L217 After Overlay (L217,4,7), DLAFRC

Matrix Size	Matrix	Description
NAFP2 X 1	$\{F_{12}\}_{1,1}$	Aerodynamic forces per generalized
NAFP2 X 1	$\{F_{12}\}_{1,2}$	coordinate and per frequency.
.	.	
.	.	
.	.	
NAFP2 X 1	$\{F_{12}\}_{1,NDOF}$	
NAFP2 X 1	$\{F_{12}\}_{2,1}$	
NAFP2 X 1	$\{F_{12}\}_{2,2}$	
.	.	
.	.	
.	.	
NAFP2 X 1	$\{F_{12}\}_{NFREQM,NDOF}$	
	EOF	

Figure 43. – S3L217 After Overlay (L217,5,4), DLPFRC

Matrix Size	Matrix	Description
2 X NDOF	$\lfloor W \rfloor_1$	Augmented normalwash, row 1
2 X NGCP	$\lfloor WG \rfloor_1$	Augmented gust normalwash, row 1
2 X NDOF	$\lfloor W \rfloor_2$	2
2 X NGCP	$\lfloor WG \rfloor_2$	2
.	.	.
.	.	.
.	.	.
2 X NDOF	$\lfloor W \rfloor_{NBOX}$	Augmented normalwash, row NBOX
2 X NGCP	$\lfloor WG \rfloor_{NBOX}$	Augmented gust normalwash, row NBOX
	EOF	

Each row is written as a 2 X N because the matrices are complex.

Figure 44. – NTP3 After Overlay (L217,4,5), FORMWS

SOLVDW calls the subroutine FUTSOL to solve the system of equations:

$$[D][\Delta cp] = W / WG]$$

FUTSOL reads the right hand sides, $[W/WG]$, by columns from the file NTP4.

FUTSOL reads the D-quasi-inverse matrix in a variable number of records from the file NTP5.

FUTSOL writes the solution, $[\Delta Cp]$, by columns onto the file NTP3 (see fig. 45) with FORTRAN unformatted write statements. Note that the matrix is complex.

NTP4

Overlay (L217,4,5) FORMWS uses a FORTRAN unformatted write statement to write the columns of $[W]$ and $[WG]$ onto the file named NTP4 (see fig. 46).

e.g., For column J of $[W]$ it uses:

```
WRITE (NTP4)  (W(I,J), I = 1, NBOX)
```

Note that both matrices are complex.

NTP5

Overlay (L217,4,6), SOLVDW, calls the subroutine COPYDQ to read the D-quasi-inverse records from the file NAETP, and writes the identical records onto NTP5. SOLVDW then calls the subroutine FUTSOL to solve the system of equations:

$$[D][\Delta Cp] = [W / WG]$$

Copying the D-quasi-inverse to NTP5 allows FUTSOL to repeatedy reposition the file without destroying the sequential processing of the file NAETP.

For a description of the records comprised in the D-quasi-inverse matrix, see the description of NAETP in reference 4.

MT, NIN, NOUT, and NATAPE

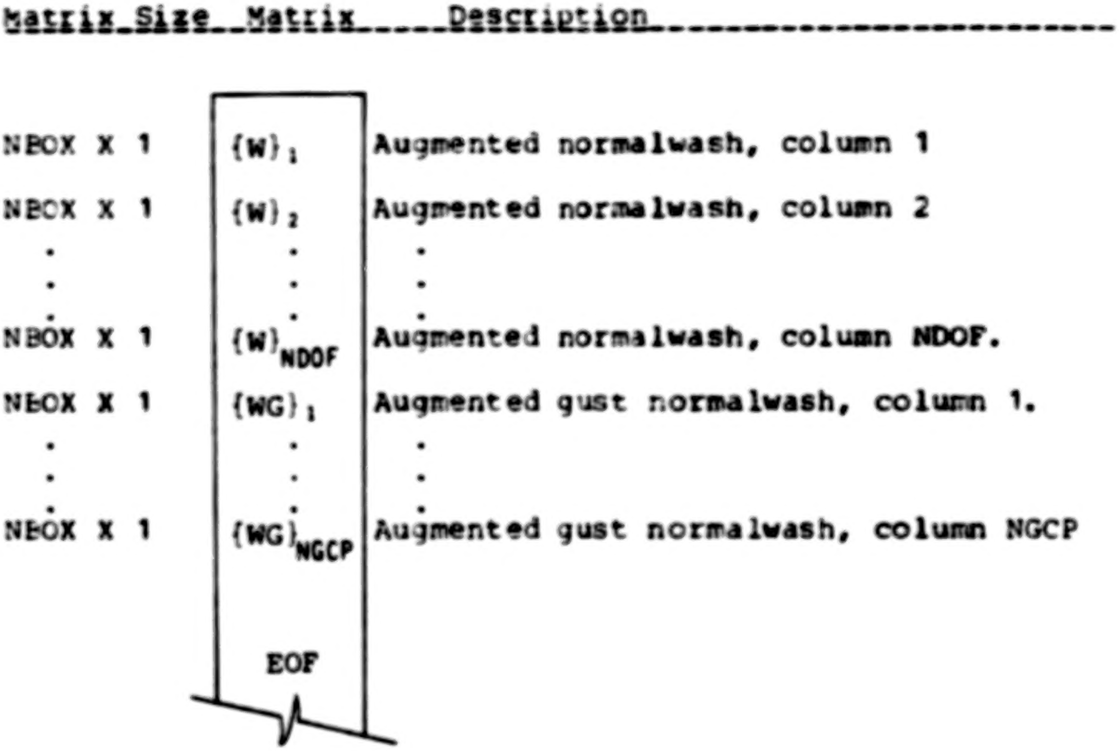
The scratch files MT, NIN, NOUT, and NATAPE are defined, used, and released within the subroutine FUTSOL. No other routines write or read these files. All of them are written/read with FORTRAN unformatted write/read statements.

NIN contains a temporary copy of the solution columns.

MT, NOUT, and NATAPE contain modified versions of the right hand sides and the D-quasi-inverse trapezoidal matrix.

Matrix Size	Matrix	Description
NBOX X 1	$\{\Delta CP\}_1$	ΔCp due to mode 1
NBOX X 1	$\{\Delta CP\}_2$	ΔCp due to mode 2
.	.	.
.	.	.
.	.	.
NBOX X 1	$\{\Delta CP\}_{NDOF}$	ΔCp due to mode NDOF
NBOX X 1	$\{\Delta CP_G\}_{NDOF+1}$	ΔCp due to gust on zone 1
.	.	.
.	.	.
.	.	.
NBOX X 1	$\{\Delta CP_G\}_{NDOF+NGCP}$	ΔCp due to gust on zone NGCP
	EOF	

Figure 45. – NTP3 After Overlay (L217,4,6), SOLVDW



Matrix Size	Matrix	Description
NBOX X 1	$\{W\}_1$	Augmented normalwash, column 1
NBOX X 1	$\{W\}_2$	Augmented normalwash, column 2
.	.	.
.	.	.
.	.	.
NBOX X 1	$\{W\}_{NDOF}$	Augmented normalwash, column NDOF.
NBOX X 1	$\{WG\}_1$	Augmented gust normalwash, column 1.
.	.	.
.	.	.
.	.	.
NBOX X 1	$\{WG\}_{NGCP}$	Augmented gust normalwash, column NGCP
	EOF	

Figure 46. – NTP4 After Overlay (L217,4,5), FORMWS

Common Blocks

Table 29 shows the common blocks used in the program and the overlays in which they are defined.

The labelled common blocks are used for communication between the primary and secondary overlays, and for communication between routines in a secondary overlays. The block names and contents are described in table 30.

Blank common is used as a variable length working area. In general, the main program of an overlay calculates the area required for arrays in the various subroutines and passes a dimension and first word addresses of the arrays through the subroutines' argument lists.

Table 29. – Common Blocks Defined in Each Overlay

COMMON BLOCK OVERLAY	AERFRQ	BODPAN	BUFF1	BUFF2	BUFF3	CHKPNT	CNSTNT	COMLOC	CRDING	CSFL	DAMPFL	DOF	DUBFLS	EOMTPS	FLXFLS	GRDPEN	HEADER	INOUT	KLOOP	MASSFL	MAXFL	NUMERR	OPTION	PARTS	PRINTO	RWBUFF	SATAP	SCRFIL	STIFFL	VARDIM	Blank
(L217,0,0)-L217									X			X					X	X			X	X	X				X	X		X	
(L217,2,0)-STRUCT						X			X	X	X	X					X	X		X	X	X	X				X	X	X		
(L217,2,1)-RSTRCT			X			X		X	X	X	X	X					X	X		X		X	X				X	X	X	X	X
(L217,2,2)-FORMAC			X	X		X		X		X		X						X				X				X	X	X		X	X
(L217,2,3)-FORM13			X	X		X				X	X	X						X		X		X	X			X		X	X	X	X
(L217,3,0)-FLXAIC	X	X	X			X	X					X		X	X	X	X	X			X	X	X	X	X		X	X			
(L217,3,1)-FLXCDS		X				X	X		X			X		X	X	X	X	X				X	X		X		X	X			
(L217,3,2)-FLXGEO		X		X		X						X			X	X		X				X	X			X		X			
(L217,3,3)-FLXMOD		X		X		X		X				X						X				X		X	X	X	X	X		X	X
(L217,3,4)-FLXFRC	X	X		X	X	X	X	X				X			X	X		X				X	X	X	X	X		X		X	X
(L217,3,5)-FLXODR	X	X		X	X	X	X	X				X		X				X				X	X	X	X	X		X		X	X
(L217,3,6)-FLXEOM	X	X		X	X	X	X	X				X		X		X	X	X				X	X	X	X	X		X		X	X
(L217,4,0)-DLAIC	X	X	X			X	X					X	X	X		X	X	X	X		X	X	X	X	X		X	X			
(L217,4,1)-DLACDS		X				X	X		X			X	X	X		X	X	X				X	X		X		X	X			
(L217,4,2)-DLAGEO	X	X		X		X	X					X	X					X				X	X		X	X		X			
(L217,4,3)-DLAMOD		X		X		X		X				X						X				X		X	X	X	X	X		X	X
(L217,4,4)-CPANDW	X	X				X	X	X				X						X	X			X	X	X		X		X		X	X
(L217,4,5)-FORMWS		X		X	X	X		X				X	X					X	X			X	X			X		X		X	X
(L217,4,6)-SOLVDW		X		X	X	X						X						X	X		X	X	X								X
(L217,4,7)-DLAFRC	X	X		X	X	X	X	X				X						X	X			X	X	X		X		X		X	X
(L217,4,10)-DLAODR	X	X		X	X	X	X	X				X		X				X				X	X	X	X	X		X		X	X
(L217,4,11)-DLAEOM	X	X		X	X	X	X	X				X		X		X	X	X				X	X	X	X	X		X		X	X
(L217,5,0)-DLPRES	X	X	X			X	X					X	X	X			X	X			X	X	X	X	X		X	X			
(L217,5,1)-DLPCDS		X				X	X		X			X	X	X			X	X				X	X		X		X	X			
(L217,5,2)-DLPGEO		X		X		X						X	X					X				X	X		X	X		X			
(L217,5,4)-DLPFRC	X	X		X	X	X	X	X				X	X					X				X	X		X	X		X		X	X
(L217,5,5)-DLPODR	X	X		X	X	X	X	X				X		X				X				X	X		X	X		X		X	X
(L217,5,6)-DLPEOM	X	X		X	X	X	X	X				X	X	X				X				X	X		X	X		X		X	X

Table 30. – Contents of Common Blocks

Each of the common blocks is described on a separate page. The following abbreviations are used to describe the individual variables.

NO. -	indicates the variable number in the common block list.
VARIABLE -	common block item name.
T -	type of variable
	I = integer
	R = real
	C = complex
	H = hollerith
DIMENSION -	number of elements in variable.
ENG. NOM. -	engineering nomenclature - symbolic.

Table 30. – Contents of Common Blocks

LABELED COMMON NAME: AERFRQ

DESCRIPTION: Frequencies at which EOM will be defined

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FREQM	R	20		Frequencies at which the aerodynamics are defined and for which the EOM are to be generated.

Table 30. – (Continued)

LABELED COMMON NAME: **BODPAN**

DESCRIPTION: Problem size in number of aero bodies and elements

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NBOD	I			Number of zero bodies (Thin and Slender)
2	NTB	I			Number of thin bodies
3	NIB	I			Number of interference bodies
4	NSB	I			Number of slender bodies
5	NSURF	I			Number of interpolation surfaces
6	NTBON	I			Number of thin bodies on the plane of sym.
7	NSBON	I			Number of slender bodies on the plane of sym.
8	NTBFON	I			Number of thin body elements on the P.O.S.
9	NSBON	I			Number of slender body elements on the P.O.S.
10	NTOTF	I			Number of force points total (NTBFP + NIBFP + NSBFP)
11	NTBFP	I			Number of thin body force points
12	NIBFP	I			Number of interference body force points
13	NSBFP	I			Number of slender body force points
14	NAFP	I			Number of aero force points (NTBFP + NSBFP)
15	NTOTC	I			Number of control points total (NTBCP + NIBCP + NSBCP)
16	NTBCP	I			Number of thin body control points
17	NIBCP	I			Number of interference body control points
18	NSBCP	I			Number of slender body control points
19	NACP	I			Number of aero control points (NTBCP + NSBCP)

Table 30. – (Continued)

LABELED COMMON NAME: BUFF1

DESCRIPTION: FIT and buffer arrays for a file created with FETAD.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FET1	R	35		the array used for a file's FIT and FET tables.
2	BUFF1	R	514		the array used for a file's I/O buffer.

Table 30. – (Continued)

LABELED COMMON NAME: BUFF2

DESCRIPTION: FIT and buffer arrays for a file created with FETAD.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FET2	R	35		the array used for a file's FIT and FET tables.
2	BUFF2	R	514		the array used for a file's I/O buffer.

Table 30. – (Continued)

LABELED COMMON NAME: BUFF3

DESCRIPTION: FIT and buffer arrays for a file created with FETAD.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	FET3	R	35		the array used for a file's FIT and FET tables.
2	BUFF3	R	514		the array used for a file's I/O buffer.

Table 30. – (Continued)

LABELED COMMON NAME: CHKPRT

DESCRIPTION: Checkout print option

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICKPRT	I			Checkout print option =0 No checkout printing requested >0 Intermediate checkout printing was requested. ICKPRT is redefined for each primary overlay. In STRUCT(L217,2,0) ICKPRT triggers the following: ≥1 Print message upon entering and leaving each secondary overlay and print $[M_1]$, $[M_2]$, and $[M_3]$ as generated. ≥3 Print items above plus in FORMAC(L221,2,2) print [CSDATA], {MCS}, $[\Phi]$, [A], and [C]. ≥5 Print items above plus a message from each VARDIM subroutine called.

Table 30. – (Continued)

LABELED COMMON NAME: CNSTNT

DESCRIPTION: Numerical Constants used in program

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	RHO	R		ρ	air density
2	VEL	R		V_T	true air-speed
3	Q	R		q	dynamic pressure $q = 1/2\rho V^2$

Table 30. – (Continued)

LABELED COMMON NAME: COMLOC

DESCRIPTION: Indicate last VARDIM array located by the subroutine LOCATR.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	JTHENT	I			Indicates the VARDIM array last located by a call to LOCATR.

Table 30. – (Continued)

LABELED COMMON NAME: CRDIMG

DESCRIPTION: Storage array for last card image.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICARD	H	8		Array to contain the last 80-column card image read.
2	KEY	H			Keyword extracted from ICARD. KEY contains the first 4 characters of ICARD plus zero fill.

Table 30 – (Continued)

LABELED COMMON NAME: CSFL

DESCRIPTION: Control surfaces adding freedoms

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ICSTPE	I			Name of the file containing the constrol surface data.
2	ICSFIL	I			Number of logical files on ICSTPE before the control surface data.
3	NCSEF	I			Number of control surfaces adding freedom.
4	NODMAX	I			Maximum number of nodes on the control surfaces.
5	NELE	I			Number of elements in [MCS].

Table 30. – (Continued)

LABELED COMMON NAME: DAMPFL

DESCRIPTION: Storage location of $\{q_{SD}\}$

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	IDTPE	H			Name of the file containing $\{q_{SD}\}$.
2	IDFIL	I			Number of logical files to skip before reading $\{q_{SD}\}$.

Table 30. – (Continued)

LABELED COMMON NAME: DOF

DESCRIPTION: Number of degrees of freedom

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NDOF	I			Total number of degrees of freedom.
2	NDOFST	I			Number of structural degrees of freedom.
3	NDOFCS	I			Number of control surface degrees of freedom.
4	NTDEF	I.			Number of mode used in DLPRES to develop gust forces at non-zero frequencies.
5	NPDEF	I			Number of mode used in DLPRES to develop gust forces at a frequency of zero.

Table 30. – (Continued)

LABELED COMMON NAME: DUBFLS

DESCRIPTION: Define files containing Doublet Lattice Data

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NGETP	H			Name of the Doublet Lattice geometry data file.
2	IGCASE	I			Geometry case to be used.
3	NAETP	H			Name of the Doublet Lattice aerodynamic data file.
4	IACASE	I			Number of the Doublet Lattice data case to be processed.
5	IAERO	I			Option from Doublet Lattice =1 only the [D] and [F] matrices are on NAETP =2 only the [Q] and $[C_p]$ matrices are on NAETP =3 [D], [F], [Q], and [CP] are on NAETP.

Table 30. – (Continued)

LABELED COMMON NAME: EOMTPS

DESCRIPTION: L217(EOM) output file names

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	EOMTAP	I			Name of the output equations of motion file.
2	EOMLOD	I			Name of the output force matrix file for loads.

Table 30. – (Continued)

LABELED COMMON NAME: FLXFLS

DESCRIPTION: Define files containing FLEXSTAB data.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	GDTAPE	H			Name of the file containing FLEXSTAB geometry data.
2	IGCASE	I			Number of data case on GDTAPE to be processed.
3	SDINDX	H			Name of the file containing the index of the FLEXSTAB SDSSTP file.
4	SDDATA	H			Name of the FLEXSTAB SDSSTP file, the file containing aerodynamic data.
5	IACASE	I			Number of the data case on SDINDX to be processed.

Table 30. – (Continued)

LABELED COMMON NAME: GRDPEN

DESCRIPTION: Define gradual penetration zones

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	XG	R	1		Gust reference point.
2	XGCP	R	NGCP		X-coordinates of gust control points.
3	XGLE	R	NGCP		X-coordinates of gust zone leading edges.

Table 30. – (Continued)

LABELED COMMON NAME: HEADER

DESCRIPTION: Header array to be written on the front of EOMTAP.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	HEAD • IHED	R I	30		The header array to be written onto the beginning of EØMTAP. Word — Content 1 — 7HDYLOFLX 2 — Program name & version 3 — Date of run 4 — NDOF 5 — NLD 6 — NPAN 7 — NFREQM 8 — Q 9 — V 10-20 — Future use 21 — Null $[M_1]$ 22 — Null $[M_2]$ 23 — Null $[M_3]$ 24 — Null $[M_4]$ 25 — Null $[M_5]$ 26 — Null $[M_6]$ 27 — Null $\{C_2\}$ 28 — Null $\{C_3\}$ 29 — Null $[f_\ell]$ 30 — Null $[\delta]$ • The two arrays are equivalenced

Table 30. – (Continued)

LABELED COMMON NAME: INOUT

DESCRIPTION: STANDARD I/O Files

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	INFIL	I			Card input file (5)
2	IUTFIL	I			Printed output file (6)
3	IPFIL	I			Punched output file (7)

Table 30. – (Continued)

LABELED COMMON NAME: KLOOP

DESCRIPTION: Current Frequency

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	IFREQM	I			Index indicating number of current frequency.
2	OMEGA	R			Current frequency in cycles/seconds.

Table 30. – (Continued)

LABELED COMMON NAME: MASSFL

DESCRIPTION: Storage location of [M]

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	MTAPE	H			Name of file containing [M], the generalized mass matrix.
2	MFILE	I			Number of logical files to skip before reading [M].
3	MMAT	I			Number of matrices to skip before reading [M].
4	MPRNT	I			Option requesting the printing of [M] if greater than 0.

Table 30. – (Continued)

LABELED COMMON NAME: MAXFL

DESCRIPTION: Maximum Field Length

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	MAXFLP	I			Maximum field length used by the secondary overlay of a particular primary overlay.

Table 30. – (Continued)

LABELED COMMON NAME: NUMBER

DESCRIPTION: Count of fatal errors detected

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NERROR	I			Number of fatal errors detected and diagnosed by the program.

Table 30. – (Continued)

LABELED COMMON NAME: OPTION

DESCRIPTION: List of program options

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	ISYM	I			Key indicating symmetric (ISYM=0) or anti-symmetric (ISYM=1) analysis.
2	IDAMP	I			Structural damping option (viscous damping, $[M_2]$, requested if IDAMP O).
3	HALFUL	R			HALFUL=1. indicates [M] and [K] are for full airplane. HALFUL=2. indicates [M] and [K] must be multiplied by 2.
4	NGCP				Number of gradual penetration control points (=1 means no gradual penetration) NOTE: (1*NGCP*35)
5	NFREQM	I			Number of frequencies at which aerodynamic data is defined (=0 means steady-state analysis is with KVALUE=0.)
6	IQUASI	I			Key requesting Doublet Lattice quasi-steady AIC solution if >0
7	ICENT	I			Key indicating that FLEXSTAB control points are at thin body box centers if ICENT=3. At control points if ICENT=0.

Table 30. – (Continued)

LABELED COMMON NAME: PARTS

DESCRIPTION: Describe modal data partitions

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NPARTS	I			Number of modal matrix partitions.
2	IPSIZ	I			Number of modes in all but last partition.
3	IPSIZF	I			Number of modes in last partition.

Table 30. – (Continued)

LABELED COMMON NAME: **PRINTO**

DESCRIPTION: Specify data to be printed

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	IPGEOM	I			=1, requests printing of geometry tables.
2	IPMODE	I			If =1 the interpolated mode shapes will be printed.
3	IPFORC	I			If =1 the force matrices written onto EOMLOD will be printed.
4	IPEQUA	I			If =1 the equations of motion matrices written onto EOMTAP will be printed.
5	IFREQP	I			Array indicating for which frequencies the force matrices and equations of motion will be printed. If IFREQP(i)>0 print data for frequency i.

Table 30. – (Continued)

LABELED COMMON NAME: RWBUFF

DESCRIPTION: The buffer required by READTP

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	BUFSIZ	H			8HBUFFSIZE
2	IBFSIZ	I			Length of BUFFRW
3	BUFFRW	R	Variable		Buffer array used by READTP to temporarily store an array read from a file. The length of BUFFRW varies for each overlay in which it is used.

Table 30. – (Continued)

LABELED COMMON NAME: SATAP

DESCRIPTION: Storage location of SA arrays

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	SATAP	H			Name of the file written by L215 (MODINT) containing the modal interpolation information arrays - (SA)'s.

Table 30. – (Continued)

LABELED COMMON NAME: SCRFIL

DESCRIPTION: Scratch file names and last file used

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	S1L217	H			Name of an L217 scratch file (=6LS1L217)
2	LSTFIL	I			Number of last file written onto S1L217 by the STRUCT overlay.
3	S2L217	H			Name of an L217 scratch file (=6LS2L217)
4	S3L217	H			Name of an L217 scratch file (=6LS3L217)

Table 30. – (Continued)

LABELED COMMON NAME: STIFFL

DESCRIPTION: Storage location of [K]

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	KTAPE	H			Name of file containing [K].
2	KFILE	I			Number of logical files to skip before reading [K].
3	KMAT	I			Number of matrices to skip before reading [F].
4	KPRNT	I			Option requesting the printing of [K] if greater than 0.

Table 30. – (Continued)

LABELED COMMON NAME: VARDIM

DESCRIPTION: Accounting data for the VARDIM variable dimension array storage scheme.

NO.	VARIABLE	T	DIMENSION	ENG. NOM.	DESCRIPTION
1	NMAX	I			Maximum number of arrays to be defined with VARDIM.
2	NENTRY	I			Number of arrays currently defined.
3	LWAVAL	I			Last word available in blank common.
4	LWUSED	I			Last word used by VARDIM in blank common.
5	LKAT	I			Pointer to the VARDIM KATLOG array in blank common (=1).
6	MAXUSD	I			Maximum core address used to store a VARDIM array during the current program's (overlay's) execution.

Table 30. – (Concluded)

LABELED COMMON NAME: Blank

DESCRIPTION: Variably dimensioned array [illegible] ge

<table>
<tr><th>NO.</th><th>VARIABLE</th><th>T</th><th>DIMENSION</th><th>ENG. NOM.</th><th>DESCRIPTION</th></tr>
<tr><td>1</td><td>|BLANK| •
|IBLNK|</td><td>|R|
|I|</td><td>1</td><td></td><td>The blank common array is loaded at the end of a program. The program uses the area between BLANK(1) and the end of field length for storage of variably dimensioned arrays - arrays with dimensions dependent upon the problem size.</td></tr>
</table>

4.0 EXTENT OF CHECKOUT

Each module of L217 (EOM) was tested during development using numerical data cases which could be easily checked. The final version of the program was tested with a set of physically meaningful verification test cases. The verification cases and the options they exercise are displayed in table 31.

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Table 31. – Options Tested by Verification Data Cases

Case Value or Option	1 FLEXSTAB N5KA	2 FLEXSTAB N5KA Anti-Sym	3 DUBFLX N5KA	4 DUBFLX H7WC	5 DUBFLX N5KA	6 DUBFLX H7WC	7 DUBLFX N5KA Quasi-Steady	8 FLEXSTAB H7WC Document Sample Problem
NDOFST	5	5	5	2	5	2	5	2
NDOFCS	0	0	0	1	0	1	0	1
SYM/ANTI	SYM	ANTI	SYM	SYM	SYM	SYM	SYM	SYM
HALF/FULL	HALF	HALF	HALF	HALF	HALF	HALF	HALF	HALF
[M]	Cards	Cards	Cards	Tape	Cards	Tape	Cards	Tape
[K]	Cards	Cards	Cards	Tape	Cards	Tape	Cards	Tape
$\{q_{SD}\}$	Cards	Cards	Cards	Cards	Cards	Cards	Cards	Cards
C.S. Freedoms	No	No	No	T_z, θ_y, θ_x	No	T_z, θ_y, θ_x	No	T_z, θ_y, θ_x
Aero Overlay	FLXAIC	FLXAIC	DLPRES	DLPRES	DLAIC	DLAIC	DLAIC	FLXAIC
NTDEF/NPDEF			1,2	1,2				
IQUASI					No	No	Yes	
ICENT	No	No						No
Gust Zones	3	3	1	1	1	1	3	1
Print	M,F,E*	M,F,E	M,F,E	M,F,E	M,F,E	M,F,E	M,F,E	M,F,E
Select Freq.			1,2	1,2	1,2	1,2		
Slender Bodies	2	2	3	1	3	1	3	1
Elements	12	12	9	10	9	10	9	10
Thin Bodies	3	3	3	4	3	4	3	2
Panels	10	10	10	16	10	16	10	16
Control Surface	No	No	No	No	No	No	No	1
Total Elements	40	40	43	62	43	62	43	62
Modes	5	5	5	3	5	3	5	3
Frequencies	1	1	2	2	2	2	2	1

* M,F,E means Modes, Forces, and Equations of Motion.

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Volume 2	FLEXSTAB 1.02.00	User's Manual	NASA CR-114713
Volume 3	FLEXSTAB 1.02.00	Program Description	NASA CR-114714
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16. Abstract

This document describes the Equations of Motion program L217 (EOM). The program formulates the matrix coefficients for a second order linear differential equation which describes the motion of an airplane relative to its level equilibrium flight condition. Aerodynamic data from FLEXSTAB or Doublet Lattice (L216) programs can be used to derive the equations for quasi-steady or complete unsteady aerodynamics. A description of the data manipulation and the matrix coefficient formulation is presented in volume I of this document. Volume II contains a description of the design and structure of the program to aid those who will maintain and/or modify the program in the future.

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